JANUARY, 1956
No. 211

ASTM Bulletin

ASTM COMMITTEE WEEK
February 27—March 2, 1956
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ASTM BULLETIN

JANUARY 1956

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ASTM BULLETIN

"Promotion of Knowledge of Materials of Engineering, and Standardization of Specifications and Methods of Testing"

Number 211 January 1956

1955 in Retrospect . . .

A Promise of Things To Come

PROBABLY the principal reason for reviewing the activities of a year that is past is for the purpose of setting the sights for the future. We like to know that we have made progress—to be sure—in line with the progress that is taking place in industry—to know that we are keeping abreast of the times. But it is even more important to be confident that we are prepared and are preparing for future demands.

Of especial concern are the developments that have taken place in the technical activities. The past year has been one of rounding out the technical committee structure—but also one of breaking new ground. A committee is now in process of organization—jointly with the American Leather Chemists Assn.—to cover the physical testing of leather, probably the oldest, certainly one of the oldest, engineering materials known to man. Similarly, plans have been under discussion for committees on carbon black and casein. Formalizing the work on hydraulic fluids, both synthetic and petroleum base, can be characterized as an amplification or extension of work already in process. The setting up of a new Committee on Electronic Materials is a recognition of the important place of these materials in industry by having them considered in a separate technical committee rather than as a part of some other committee as heretofore. Of particular significance is that in setting up this committee it is made the first to be recognized as a "Use" or "Materials for a specific application" committee.

The strictly "new" is the setting up of an Advisory Committee, a committee functioning in an administrative sense, in the field of nuclear energy. The Society's Committee E-10 has of course functioned with respect to the use of radioactive isotopes and this committee has also concerned itself with radiation-induced changes in materials. Other technical committees have also been cognizant of the need for reviewing their standards in the light of the use of materials in nuclear reactors and other application where the material is exposed to radiation—quite apart from the study of properties of material where radiation is used in processing them in manufacture. For example, Committee D-19 on Industrial Water sponsored a Symposium on High-Purity Water, a subject of direct interest in the operation of nuclear reactors as well as other less glamorous, high-temperature, high-pressure generators. The number of individual papers being submitted to and published by the Society on the effect of radiation on materials or concerning the necessary techniques for testing and using radioactive materials are indicative of the growing interest in the subject. The new Advisory Committee on Nuclear Energy will coordinate work of this kind in the technical committees as well as promote research and standardization in this area.

Much of the Society's work centers around the Annual Meeting in June, so the account of the meeting as given in the July issue of the BULLETIN will provide the background for the year's accomplishments. The many symposia held lead to the various special publications such as the Symposium on Metallic Materials for Service Above 1600 F. The many actions on standards (some of which are pointed up in the accounts below) are crystallized in the 1955 Book of Standards. This, if anything, can be considered the high point of the year so far as publication is concerned. In fact it is monumental—2200 standards, 12,000 pages. While the Books themselves, in seven Parts, are just now appearing (see p. 16), the consideration on the part of the committees, actions by the Society or by the Standards Committee, even the editorial work have been completed long since, and the Book makes of 1955 a year of high achievement.

The extent of the present publication efforts may be placed in perspective by examining the size of publications in recent years. The Book of Standards, which is published every third year, contained 7000 pages in 1946, 8300 in 1949, and 10,000 in 1952 as compared with 12,000 pages for this year's edition. Thus, the number of pages of standards published by the Society has nearly doubled in less than ten years. There has been an even sharper increase in total pages of Special Technical Publications of the Society which have increased from about 450 pages in 1946, and about 850 in 1949, to about 2350 average for each of the last few years. Other publications, such as the BULLETIN and *Proceedings* have remained about the same each year and while they add to the total of pages published, they do not affect the trend.

Correspondingly, membership, finance, and support have increased in accord with the Society's increased activities and service to industry and to the nation.

Only the barest résumé of the Society's activities for the past year can be given in the space available. Behind each item discussed below, there are hundreds—even thousands—of man hours of effort on the part of committee members.

METALS

International Activities Highlight 1955 Developments

Since 1950 Committee A-1 on Steel has been receiving communications through the American Standards Association of the activities of Technical Committee 17 on Iron and Steel of the International Organization for Standardization. The U.S.A. is continuing to participate on an observer status in this work. This past year the copper and brass industry and the cast iron industry both entered into international work. Early in 1955 ASTM Committee B-5 advised the ASA to accept the secretariat of ISO 26 on Copper and

Copper Alloys; the Advisory Subcommittee of Committee B-5 will act as the advisory group to ASA in this activity. American delegates to the June 13 and 14 meetings in Stockholm were W. D. France, Scovill Mfg. Co. (B-5 vice-chairman) and V. P. Weaver, American Brass Co. (B-5 secretary). Mr. Weaver acted as secretary at the meeting.

Realizing the importance to the American cast-iron industry of international standardization, late in 1955 ASTM Committee A-3 recommended American participation in the work of ISO 25 on Cast Iron. Following clearance of this participation, it was decided that the Advisory Subcommittee of Committee A-3 would advise the ASA regarding American practice. Two ASTM members represented the U.S.A. at the September 28, 29, and 30 meeting of ISO 25 in London—H. W. Stuart, U. S. Pipe and Foundry Co. (A-3 chairman) and H. W. Lownie, Jr., Battelle Memorial Inst. (chairman of A-3 Subcommittee VI on General Castings).

At both the Stockholm and London meetings, the American delegates were impressed very favorably with the personnel and with the quality of the discussions. All delegates seemed willing to cooperate in the international atmosphere, with the merits of all proposals given proper consideration. Many suggestions of the American delegates were adopted as a basis for future activities of the ISO Committees.

Completed Standardization Activities

Specifications for two steel products which have needed standardization for years were finally approved. One of these—Tentative Specifications for Galvanized Steel Transmission Tower Bolts (A 394 – 55 T)—was greatly desired by the electric power companies. Two years ago a special group was organized by Committee A-1 to deal with this pressing problem. The group consisted of representatives of companies producing tower bolts and most of the companies building and maintaining power lines. After many drafts which coordinated conflicting viewpoints, standardized mechanical properties, tests, and dimensions were agreed upon by the group. The Tentative Specifications for Alloy Steel Chain (A 391 – 55 T) were the result of the organization of a group of chain producers and users in Committee A-1. Standardization of this product was requested at two different times, first by consumers and later by the manufacturers. Once organized, this group rapidly arrived at mutually satisfactory requirements which are reflected by ASTM Specifications A 391.

Mainly as a result of requests by power companies, specifications and recommended practices for galvanized assemblies were considered and approved. These included:

Tentative Specifications for Zinc Coating (Hot Dipped) on Assembled Steel Products (A 386 – 55 T).

Tentative Recommended Practice for Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies (A 384 – 55 T).

Tentative Recommended Practice and Design Suggestions for Providing High-Quality Zinc Coatings (Hot Dip) on Assembled Products (A 385 – 55 T).

These standards include such products as steel windows, transformer parts, vault frames, grates, handling equipment, and conveyors.

In the field of corrosion-resisting steels, a procedure was standardized for measuring the relative susceptibility of austenitic steels to intergranular attack. This is the Tentative Recommended Practice for Conducting Acidified Copper Sulfate Test for Intergranular Attack in Austenitic Stainless Steels (A 393 – 55 T). The electrolytic oxalic acid etching test was added to the Tentative Recommended Practice for Boiling Nitric Acid Test for Corrosion-Resisting Steels (A 262 – 55 T). This new procedure qualifies the corrosion rate of materials in a much faster manner. However, materials that do not pass this test should be subjected to the nitric-acid procedure before rejection.

Cast Ferrous Metals

Turning to cast ferrous metals, it is of general interest to call attention to the completely revamped Specifications for Pig Iron (A 43), which was the first specification written by Committee A-3 (1904). During the past year it was found necessary because of modern industrial practice on grades and chemical compositions of pig iron generally available, to rewrite the specifications. The new ductile or nodular irons also were further standardized. In 1951, grades 80-60-03 and 60-45-10 were included in the present Standard Specifications for Nodular Iron Castings (A 339 – 55). The figures making up the designations of these grades refer, respectively, to the tensile strength, yield strength, and percentage elongation. Following publication, many references to Specifications A 339 have appeared in trade journals and technical articles. Now a 60-45-15 grade of nodular iron particularly for pressure vessel construction, with many special requirements on repairing, has been included in the Tentative Specifications for Cast Nodular Iron for Pressure Containing Parts for Use at Elevated Temperatures (A 395 – 55 T). Also 120-90-2 and 100-70-3 grades for highly stressed parts appear in the Tentative Specifications for High-Strength Nodular Iron Castings (A 396 – 55 T). Not to be outdone by this new material, the pearlitic malleable foundries have made advances in the production of pearlitic malleable iron and the revisions of the Tentative Specifications for Pearlitic Malleable Iron Castings (A 220 – 55 T) reflect this.

Copper and Brass

The copper and brass industry, as a result of its representatives' meeting in Committee B-5 with consumer representatives, is ready to offer two relatively new products to purchasers when ordered to ASTM specifications. These are the Tentative Specifications for Tellurium Copper Rod (B 301 – 55 T) and the Tentative Specifications for Threadless Copper Pipe (B 302 – 55 T). Tellurium copper rod is especially adaptable to machining operations and has a minimum conductivity of 90 per cent I.A.C.S. Threadless copper pipe is intended for piping systems assembled with brazed joint pipe fittings. The table of dimensions, weights, and tolerances covers pipe from $\frac{1}{2}$ to 12 in. in nominal size. In the application of copper electrical conductors, there has been a great need for one suitable for high-temperature work. As a result the Tentative Specification for Silver Coated Soft or Annealed Copper Wire (B 298 – 55 T) was developed. This should prove a great service to many users, including the Military, since previously there was no uniformity of requirements.

Another of the relatively new industrial metals is titanium. The Tentative Specifications for Titanium Sponge (B 299 – 55 T) establishes long-needed standard grades. Very detailed procedures for sampling and testing are included.

Slowly but surely, metal powder structural parts are being standardized and entering into the industrial picture. This past year the Tentative Specifications for Copper-Infiltrated Iron Parts (B 303 – 55 T) were agreed upon. Structural iron parts of 65,000, 75,000, and 100,000 psi tensile strength are covered.

Metals Testing

The ASTM committees concerned with testing metals have developed

several particularly significant procedures, which will serve as yardsticks to measure the quality of metal products. Committee E-7 has been at work nearly four years to provide the Reference Radiographs for Steel Welds (E 99 – 55 T) intended as an aid in evaluating weld soundness. These are reproduced from master radiographs of official sample weld plates which will be kept in the custody of the ASTM. The radiographs are mounted in notched Keysort borders and illustrate the different types of discontinuities as well as varying degrees of severity. A new Tentative Method for Dry Powder Magnetic Particle Inspection (E 109 – 55 T) provides a uniform procedure for large parts such as castings or weldments. The method was written primarily so that consistent results could be obtained upon which acceptance standards may be based.

Much has been published on ultrasonic testing during the past four or five years. A great difficulty in applying ultrasonic testing to the testing of materials has been the human factor of knowing the limitations of the procedures employed. Committee E-7 has had ultrasonic testing under consideration since the earliest days of its introduction as an inspection tool. Late in 1955 the Tentative Recommended Practice for Ultrasonic Testing by the Resonance Method (E 113 – 55 T) and the Tentative Recommended Practice for Ultrasonic Testing by the Reflection Method Using Pulsed Longitudinal Waves Induced by Direct Contact (E 114 – 55 T) were published.

Those involved in metallography should be very happy over two developments in ASTM Committee E-4. The existent methods for grain size determination have developed in the various metal branches and consequently each has its own peculiar requirements. Recognizing that a grain is essentially the same entity whether it be in steel, copper, nickel, aluminum, magnesium, etc., the Tentative Method for Determining the Average Grain Size of Metals (E 112 – 55 T) has been established. This method combines all the existing procedures for grain size determination of metals and is a monument to ASTM technical committee activities. One of the great difficulties in metallography has been standardization of nomenclature. This is necessary in order to discuss clearly the various phases of the metallographer's art or science. Some few definitions were agreed upon in 1921 which were revised and finally standardized in 1927 as the Standard Definitions of Terms Relating to Metallography (E 7 – 27). Since that time these definitions have been untouched while metallographic procedures have grown by leaps and bounds. Several years ago an extensive list of appropriate terms was compiled as needing definitions. Review after review followed. With this year's revision the original Definitions E 7 – 27 of 2 pages have grown to Definitions E 7 – 55 T with 41 pages.

Active Investigations in Progress

The steel forging industry has been greatly concerned over the failure of a turbine spindle resulting in fatalities in one of the Midwestern power stations. As a consequence, the manufacturers and purchasers have organized a Task Group on Brittle Fracture of Forgings. This task group has convened many times during 1955. All-day discussions on the causes of failure and methods of manufacture and inspection to prohibit further failures have been most exhaustive. Several papers presented at the 1955 ASME Annual Meeting were based on the discussions in this group. Still another weighty problem in steel forgings has been the effect of hydrogen content, and another task group has been discussing hydrogen. A sampling method for hydrogen analysis is being written and Committee E-3 on Chemical Analysis of Metals has been asked to write a method of analysis.

The old problem of stress-corrosion cracking of stainless steels is still a live one. A special group is actively investigating the current research programs dealing with the subject to see if it is being given proper consideration.

Committee B-8 on Electrodeposited Coatings has recognized several pressing problems and organized several special sections to investigate (1) the performance of electrodeposited tin and tin alloy coatings, (2) the hardness of electrodeposited coatings, (3) the ductility of electrodeposits, and (4) the methods of measuring stress in electrodeposited coatings.

Symposia, Special Technical Publications, and Special Committee Reports

Symposia of special interest during the year included those at the Annual Meeting on:

(1) Atmospheric Corrosion, including nine papers of authoritative general information. (2) Metallic Materials for Service Above 1600 F, arranged by the ASME-ASTM Joint Committee on Effect of Temperature on the Properties of Metals; thirteen papers describing metals and tests for use under these most severe conditions were of great interest. (3) Fatigue, a subject of continuing interest because of the use of fatigue values in design. Committee E-9 has pursued a vigorous policy in sponsoring papers through the years in order to make this type of information generally available.

The precision of temperature measurement and control which can be specified for high-temperature test work has been often questioned. As a start in defining such precision a Panel on Pyrometry held an open session at the 1955 Annual Meeting. This discussion will be published by the Society.

Since most high-temperature materials are used in atmospheres of water vapor or some products of combustion, the design engineer must always be concerned with the effects of environment on the creep rate and the ductility of the material. During 1955 Committee Week, the Joint ASME-ASTM Committee on Effect of Temperature sponsored still another Symposium on the Basic Effects of Environment on the Strength, Scaling, and Embrittlement of Metals at High Temperatures.

The use of corrosion-resistant steel in architectural and structural applications has become of increasing importance. Previous reports on corrosion effects in major installations have been published. This year a report has been published of further inspections of these installations as well as several new ones. Major installations include:

525 William Penn Place, Pittsburgh
Gateway Building, Pittsburgh
Heppenstall Building, Pittsburgh
Allegheny Ludlum Research Lab., Brackenridge
Empire State Building, New York City
Universal Pictures Building, New York City
Chrysler Building, New York City
Boardwalk Installations, Atlantic City
Philadelphia Savings Fund Building, Philadelphia
Pennsylvania Building, Philadelphia
Reading Railroad "Crusader" Train

General observations and recommendations are included in this report.

The protective value of composite copper-nickel-chromium platings on high-carbon steel has been under investigation for a number of years. Numerous panels of varying types of composite coatings have been exposed to different atmospheric conditions for over seven years. This year a progress report of the results has been published giving the inspection data in detail and drawing certain conclusions of value to anyone employing chromium-plated articles.

One of the special technical publications issued by ASTM in 1955 was originally intended only as a work sheet for a subcommittee charged to write specifications for high-temperature super-strength alloys. However the grapevine worked to perfection and the originators were soon faced with overwhelming requests for copies. As a result the Compilation of Chemical Compositions and Rupture Strengths of Super-Strength Alloys has been published by the Society. This publication lists the name, nominal chemical composition, characteristic rupture strengths for 100 and 1000 hr, and the patentee for approximately 100 domestic and 41 foreign alloys.

Anyone interested in a factual and comprehensive report on the status of metal powder products in American industry should read the 1955 Gillett Lecture by F. V. Lenel. Every design engineer should include this pamphlet, with its clear-cut statements on typical applications and properties, in his file.

CONSTRUCTION MATERIALS

Cement, Mortar, Concrete

False Set Covered by New Method

The use of mechanical mixing in the testing of mortars to replace handmixing, has led to the need for adjustments in the physical test requirements in specifications for cement. Committee C-1 on Cement revised several of its test methods accordingly and data are being studied with a view to modifying present specification levels.

The Specification for Masonry Cement (C 91), one of the most widely used standards on cement, received a major revision in order to embody the use of the same strength and air-entrainment testing procedure currently used in the corresponding Federal specification.

A new specification for slag cement (Tentative C 358) was completed and accepted by the Society, representing coverage of a material which has a long record of use.

Valuable data are included in major reports recently released by the committee for publication. Subjects include: the level of strength development of domestic portland cements throughout the country, the effect of mechanical mixing on the compressive and flexural strength of portland cement mortars, and cooperative studies of a performance test for the potential sulfate resistance of portland cement. These reports will appear in the 1955 *Proceedings*.

The measurement of false set of portland cement is now covered in a new tentative method accepted by the Society (C 359).

With fairly complete coverage of test methods, Committee C-2 on Magnesium Oxychloride and Magnesium Oxysulfate Cements has felt the need for standard definitions of terms. As partial fulfillment of this need, a group of definitions has been completed and presented to the Society for acceptance.

Committee C-3 on Chemical-Resistant Mortars became of age in 1955 as reflected by a complete reorganization and expansion of membership. The nature of its activities has suggested two groups of subcommittees—one on materials including silicate, resin, sulfur, and hydraulic mortars, and another on properties, including mechanical, physical, chemical, and recommended practices and identification.

The major activities in Committee C-7 on Lime during the year were in the field of chemical lime and the new subject of the use of pozzolanic material with limes. Specifications for lime for silica brick, sand-lime brick and lime for hypochlorite bleach manufacture have been under development or revision. Two test methods on lime neutralization were evaluated with a further round-robin test program under way.

The determination of the soundness of lime continues to be the major research problem of the committee, with important work at Massachusetts Institute of Technology.

The Significance of Tests of Concrete and Concrete Aggregates is a very comprehensive Special Technical Publication sponsored by Committee C-9 on Concrete and Concrete Aggregates. A group of 39 articles was prepared by committee members, each considered an authority on the particular subject covered.

An innovation in specification coverage was introduced during the year with the preparation of a specification for packaged dry, pre-mixed materials for mortars and concrete, now published as information only.

A new means of determining the plasticity or consistency of fresh concrete was recognized in the acceptance by the Society of a Tentative Method of Test for Ball Penetration in Fresh Portland-Cement Concrete (C 360).

Many projects advanced during the year dealt with various properties and characteristics of concrete and aggregate which are significant in service—for example, the old problem of perfecting a suitable freezing-and-thawing test and the new problem of pore structure of aggregate.

Following the publication of a proposed method for evaluating efflorescence, a new series of round-robin tests has been under way in Committee C-12 on Mortars for Unit Masonry. Another test series for evaluating sands was inaugurated following agreement reached on a reference grading.

A reorganization of Committee C-13 on Concrete Pipe effected during 1955 will enable the committee to operate more efficiently as well as to cope with important problems ahead. New bylaws have set up provisions for an advisory subcommittee, standing subcommittees for jurisdiction over each of the complete specifications, and other subcommittees or task groups for special problems. One such special subcommittee was authorized for studying absorption tests.

Two new concrete pipe specifications were accepted by the Society, these being in the field of reinforced low-head pressure pipe—one for use as a pressure conduit with hydrostatic heads not exceeding 100 ft (C 361), the other for sewage, industrial wastes and storm water under internal operating heads up to 50 ft (C 362).

Ceramics, Masonry, Thermal Insulation

Above-Grade Waterproofing to be Studied

Three new industrial surveys were completed in Committee C-8 on Refractories covering refractories for coke ovens, soaking pits for steel ingots and reheating furnaces. The use of the flame photometer method in the analysis of lithium, sodium, and potassium in refractories has been perfected and is now being reviewed.

A new test method completed and now an ASTM Tentative is the Method of Test for Bulk Density of Granular Refractory Materials (C 357). A new

classification of fireclay brick has been published as a suggested classification, in which the various types and classes are arranged according to their normal and characteristic properties important in their use.

In addition to further refinement in existing standards under its jurisdiction, Committee C-15 on Manufactured Masonry Units made progress in the direction of coverage of additional materials in its field. The difficult field of preparing standards on waterproofing materials for unit masonry walls was analyzed critically, and the new subcommittee responsible has concluded that for the present, it would confine its activities to materials used above grade. Proposed specifications for industrial floor brick and for ceramic tower packings, both in the category of chemical-resistant units, were prepared, subject to further review. A report on a series of tests on sulfur capping showed an indication that higher compressive strengths were obtained with sulfur rather than with plaster-of-Paris capping. However, further study of this problem is being made before definite recommendations are presented.

Continued efforts on the part of Committee C-16 on Thermal Insulating Materials during the year to increase the coverage of standards in the thermal insulating materials field resulted in the acceptance by the Society of a new tentative specification for molded cork pipe insulation for low temperatures (C 339). In addition, a new Tentative Method of Test for Linear Shrinkage of Preformed High-Temperature Thermal Insulation (C 356) was accepted. An additional method for the measurement of water vapor transmission for use for thick samples was completed by a subcommittee. Two proposed specifications have been prepared for mineral wool felt insulation (industrial type) for elevated temperature up to 600 F, and for batt or blanket-type thermal insulation for buildings, respectively. A final draft of an emissivity test method was accepted for letter ballot.

A new subcommittee on reflective insulation was formed and held meetings during the year, with the preparation of definitions of the various types of insulation in which reflective materials are included, as its first project.

An expansion of the activities in Committee C-21 on Ceramic Whiteware was inaugurated with new sections on cermets and on ferrites established or authorized. Increased activity also occurred in the Section on Titanates and Zirconates, which has considered tests on barium titanate, particularly the development of a special firing technique (see also Electrical Insulating Materials).

Twenty-nine additional definitions of terms were submitted to letter ballot of the committee, which will augment an existing list of some 60-odd definitions already published. There was much activity by the Section on Fundamental Properties of Products, which resulted in the acceptance by the Society of six new Tentative Methods of Test for: Linear Thermal Expansion of Fired Whiteware Products by the Dilatometer Method (C 372); Water Absorption, Bulk Density, Apparent Porosity, and Apparent Specific Gravity of Fired Porous Whiteware Products (C 373); Moisture Expansion of Fired Whiteware Products (C 370); Resistance of Ceramic Tableware to Impact (C 368); Modulus of Rupture of Fired Cast or Extruded Whiteware Products (C 369); and Sieve Analysis of Nonplastic Pulverized Ceramic Materials (C 371). Two additional methods completed and ready for presentation to the Society are for the measurement of thermal conductivity and for compressive strength of fired whiteware materials.

The development of standards for raw materials, as well as for finished products, continued during the year in Committee C-22 on Porcelain Enamel. New test methods accepted by the Society included a Tentative Method for Fusion Flow of Porcelain Enamel Frits (Flow-Button Method) (C 374) and a Classification of Water Used in Milling of Porcelain Enamel (C 375). In addition, two methods were presented for publication as information only—a suggested method of test for set characteristics of porcelain enamel clays (slump method) and a proposed method of test for determining the sag resistance of steel sheets for porcelain enameling. Bibliographic studies relating to the behavior of testing of porcelain enamel have been under way by the Subcommittee on Research for the use of the working subcommittees on materials and finished products. The review of approximately one third of the definitions of terms, now published under the ASTM Designation of Tentative C 286, was completed during the year.

Standards for Nation's Expanding Highway Construction

(See also Cement, Mortar and Concrete)

Materials for use in bituminous surface treatments are now covered in two new standards completed by Committee D-4 on Road and Paving Materials and accepted by the Society. A completely rewritten tentative specification to cover the quality and grading of crushed stone, crushed slag, and gravel for single, double, or multiple bituminous service treatments (D 1139) and a new tentative recommended practice for quantities of aggregate and bituminous material for single, double, and triple bituminous surface treatments (D 1369) comprise this coverage. A host of projects in the more than 30-odd subcommittees achieved definite progress during the year. An example of one of these projects is the preparation of a method of test for stability and flow values of compressed bituminous mixtures, with the description of the Marshall test apparatus and procedure distributed to the committee. New developments such as the use of flame photometer procedures and radioactive tracer developments were used in the evaluation of the percentage of the retained bituminous coatings on aggregates. A new method was completed for testing soils for water-soluble constituents.

Judgment factors in the testing and evaluating of soils was formally discussed by Committee D-18 on Soils for Engineering Purposes during the Annual Meeting of the Society. The importance of the proper interpretation of standard test methods, many of which are empirical in nature, was stressed. The work of the committee was critically reviewed, with the general consensus that the committee should continue its efforts for the development of standard tests. Significant advances were made in developing sampling methods including the use of auger borings, split spoon, and thin-walled tube sampling.

Buildings and Structures

An important revision of the standard specification for gypsum wallboard (C 36) by Committee C-11 on Gypsum was the addition of requirements for Type X which is a board with specially formulated core to provide greater

fire resistance for the same thickness. Specifications for accessories received attention, such as for paper used in gypsum board products, mold resistance of face paper, and for annular ringed gypsum wallboard nails.

An important step was achieved in 1955 by Committee C-19 on Structural Sandwich Constructions in the actual installation of sandwich panels and cores at two of the ASTM exposure test sites. Flatwise compressive strength, delamination strength of honeycomb type, and the measurement of thickness of sandwich cores may now be determined as a result of three test methods completed by the committee and accepted by the Society. The edgewise compressive strength of flat sandwich construction was also accepted as an ASTM method.

The first ASTM standards on acoustical materials were completed by Committee C-20 on Acoustical Materials and accepted by the Society, these being Tentative Methods of Tests for Strength Properties of Prefabricated Architectural Acoustical Materials (C 367). Procedures for measuring such properties as structural hardness, friability, sag, and linear expansion and contraction are included in this standard. Significant progress was made in the preparation of test methods for measuring the basic property of sound absorption. The impedance tube method has been accepted by the committee, and sufficient correlation has been obtained between laboratories using the reverberation room method so that a draft of a proposed method has been prepared. Agreement was reached on a suitable method for determining the aging properties of adhesives used in the application of acoustical tile. With this agreement, an extensive round-robin test was inaugurated in order that data may be obtained for use in the proposed specification for adhesives, which has been under consideration for the past two years.

The Wood Pole Research Program of Committee D-7 on Wood progressed rapidly during 1955, with test programs being completed on all of the untreated species, such as Western Larch, Western Red Cedar, Douglas Fir, Lodgepole Pine and Southern Pine. Interim reports have been published for the benefit of the contributors to the research fund, with a further report completed but unpublished as yet on a comparison of the machine method with the crib method. Work on the subject of durability and exposure was inaugurated with the activation of a subcommittee whose first objective is the standardization of a soil-block method for the accelerated testing of wood preservatives and the natural decay of wood.

Committee D-8 on Bituminous Waterproofing and Roofing Materials celebrated its 50th Anniversary in 1955 with a luncheon held during the Annual Meeting in Atlantic City. One new tentative method of test was accepted by the Society: for the determination of contact compatibility between asphaltic materials using the Oliensis Test (D 1370).

The fire-retardant characteristics of roof coverings against fire originating outside the building on which they have been installed can now be measured by a new method of fire test developed by Committee E-5 on Fire Tests of Materials and Construction and accepted by the Society under the designation E 108. Three methods are included: the intermittent flame exposure test, the spread-of-flame test, and the burning brand test. A complete revision of the Methods of Fire Tests of Door Assemblies (E 152) was also accepted.

The investigation and research at the Forest Products Laboratory on a small-scale tunnel test progressed to the extent that a test on samples identical with those tested according to the ASTM Tentative Method of Fire Hazard Classification of Building Materials (E 84) were made with final report yet to be released. Consideration was given to a new type of flame-spread test known as the radiant panel test, as well as to a construction materials calorimeter test.

The significant activity in Committee E-6 on Methods of Testing Building Constructions during the past year centered around the critical review of the present status and future of the committee, resulting in the laying of plans for a period of reorganization. The committee sponsored a discussion at the Annual Meeting based on a paper presented on the philosophy of load tests for structures.

ORGANIC MATERIALS, CHEMICALS, ETC.

Paper and Paint

Putty, Glazing and Calking Compounds—a New Project

The committee concerned with standards for paper and paper products has been reviewing its standards and incorporating revisions where necessary. The method for resistance of paper to passage of air (D 726) is being completely revised. A tentative revision of this standard was included with the Committee D-6 Annual Report.

The paperboard used in containers has been the subject of study with emphasis on development of test methods for wet bursting strength and mold resistance.

Materials which go into shipping containers and particularly the interior packing materials are receiving special attention. In order to evaluate the efficacy of the materials in containers, the finished containers in loaded condition are subjected to a variety of punishing operations including vibration, tumbling in a revolving drum, and dropping from various heights. Revision of test methods such as these is currently in progress. The objective is to simulate as closely as possible conditions encountered in actual shipping operations.

One of the hazards to which shipping containers are subjected is encountered when containers are stacked in a warehouse or in a freight car and the containers low in the stack are subject to impact and compression loads. The committee concerned has been working for some time on the development of a stacking test, and the first collaborative report on round-robin studies of the stacking tests has been completed. The results are being used as the basis for further collaborative work.

Emphasizing the importance of flammability characteristics of surface coatings, Committee D-1 developed two new fire retardancy methods during the year. Also developed was a recommended practice for reporting particle size (D 1366). This should serve to improve the uniformity of reporting particle size which heretofore has been rather confusing.

The committee has undertaken work on putty, glazing, and calking compounds. Standards for these materials will be handled by a new subcommittee.

Development of standards for latex and emulsion paints received impetus with the development of a program of work to be undertaken by a recently organized subcommittee on this subject.

Rubber, Textiles, Plastics, Adhesives

During the past year, the transfer of the Government-owned synthetic rubber plants to industry has been completed. Prior to this sale of plants, the specifications for synthetic rubber were Government rather than industry.

With the transfer of the plants to industry there developed a need for industry to take over the specifications and test methods relating to synthetic elastomers. Toward this end, the ASTM rubber committee has established a new group which, for the present, will confine its attention to test methods.

The rubber committee has also extended itself in another direction — that of development of standards on compounding ingredients for rubber. Heretofore the committee has confined its efforts to properties of the rubber itself, and with this expansion into ingredients, the committee will develop standards for reinforcing pigments, accelerators, and various other materials which are a part of the rubber recipe.

An extensive glossary of terms relating to rubber and elastomers has been prepared and will shortly be published. This glossary should serve as a useful reference and guide on the terminology used in the rubber industry. Not only are definitions included in the glossary but also interesting and useful background information on a number of terms.

Rubber is often used in conjunction with other materials; an example being with metal to which rubber may be bonded with an adhesive. The committee has revised a portion of the method for testing adhesion of rubber to metal (D 429).

ASTM has long cooperated with the Society of Automotive Engineers through a joint committee operating in conjunction with Committee D-11 on Rubber. During the year this group has revised the specification for automotive and aeronautical rubber compounds (D 735) to include several new grades of silicone elastomers.

Pilling Method for Textiles Developed

Anyone who has experienced the formation of little lumps of fibers on his socks or sweater will be glad to know that the textile committee has developed a new method for evaluating the pilling characteristics of textiles. The use of this test method should lead the way to the development of textile fabrics which are less susceptible to pilling. Other standards developed by the textile committee during the year include methods for abrasion of yarns, methods of testing elastic fabrics, tests for nonwoven fabrics, and methods of testing fineness of mohair tops.

The 1955 Marburg lecturer was Walter Hamburger, a longtime member of the ASTM textile committee. The Marburg lecture on textile structures as engineering materials was presented both at the Annual Meeting and later at a meeting of the textile committee.

Plastic Pipe Standards Imminent

Expansion of the Society's work on developing standards for plastics is reflected in the activities of several newly organized subcommittees. One of these is the Joint Subcommittee on Plastic Pipe cosponsored with the Society of the Plastics Industry. Another is the Subcommittee on Reinforced Plastics. Activities of these groups have been fully covered in previous issues of the BULLETIN as well as in the annual report of the committee.

An item of particular interest in connection with plastic pipe is the action of the American Standards Assn. to establish a sectional committee on plastic pipe under joint sponsorship of the Society of the Plastic Industry and The American Society of Mechanical Engineers, the scope of which will include standardization of dimensions. ASTM will be represented.

One of the important actions of the subcommittee concerned with permanence of plastics was the referral to Committee E-1 on Methods of Testing of a project to develop uniform recommended practices for operation of carbon-arc exposure apparatus. Work is actively going forward in the permanence group to develop a fluorescent light method for exposure of plastics to replace the method currently used which employs an incandescent light source, the equipment for which is no longer readily available.

In order to provide a forum for the introduction of new ideas with regard to test methods, the Subcommittee on Research of the Plastics Committee has sponsored several technical papers sessions followed by discussion periods. Subjects included flow properties of thermoplastics, stress crazing, dynamic properties, impact testing, and methods of chemical analysis.

The Plastics Committee has been active in international activities since it heads up a group responsible for U. S. participation on ISO 61 on Plastics. The U.S. participated in the July 1955 meeting of ISO 61 held in Paris where a number of draft proposals were acted upon.

The availability of standard methods of tests for engineering adhesives has contributed in no small measure to the increasingly wide use of these materials as a means of attachment, replacing such conventional attaching methods as nails and screws. The ASTM Committee on Adhesives is concerned not only with adhesives for wood and for bonding metal to metal but also such adhesives as are used for bonding paper in shipping containers and bonding labels to bottles. Some adhesives, such as are used in shipping containers are susceptible to attack by roaches and by rats. During the year, the committee has developed new tentative methods of test for susceptibility of adhesives to attack by these pests. The availability of these methods will facilitate the development of roach and rat repellents which can be added to adhesives, and it will also enable the selection of adhesives which are inherently resistant.

Methods under development include tests for nonvolatile content of urea-formaldehyde resin solutions, peel resistance of adhesives, and test for nonvolatile content of aqueous adhesives.

Also under development is a specification for room-intermediate-temperature setting adhesives, recommended practice for conducting creep tests of metal-metal adhesives, test for hydrogen ion concentration (pH) of dry adhesive films, and specification for adhesives for high-speed automatic machine labelling of glass bottles.

Chemicals

One of the important characteristics of an antifreeze solution is that it be noncorrosive to cooling systems. An important accomplishment of the engine antifreeze committee has been the development and publication during the year of a method for determining the corrosiveness to metals of antifreeze solutions. This is a laboratory test which can distinguish between coolants that are definitely deleterious from the corrosion standpoint and those that are suitable for further evaluation. Development of this test is the result of several years of concentrated effort on the part of the committee.

The committee is currently engaged in revising the Method of Test for Water in Concentrated Antifreeze (D 1123). In order to eliminate errors that occur in testing borate in borate-inhibited antifreeze using the iodine reagent method, the committee has initiated a collaborative test program.

Correction Tables for Aromatics Being Developed

The committee concerned with industrial aromatic hydrocarbons has been

concentrating its efforts on development of methods for determining a number of properties of naphthalene, pyridine, quinoline, and phenol. Currently under development also is a method utilizing infrared spectroscopy for determining isomers in nitration grade xylene.

The committee during the year initiated a project to develop temperature correction tables for benzene, toluene, and the xylenes. These tables will enable a correction or conversion of the volume of the liquid determined at one temperature to that at another temperature, similar to tables developed for petroleum products.

One of the oldest industries in this country is naval stores. It received its name from the early use of pine pitch for calking the seams in naval vessels. Since the early days when the naval use was the major one, many changes have taken place in the industry, and naval stores and chemical products obtained therefrom are used in a variety of applications including, particularly, paper sizing and surface coatings. The Committee on Naval Stores published as information, in its annual report, proposed methods for testing crystallization tendency of gum rosin and method of testing tall oil skimmings. Gum rosin is that derived from the oleo resin obtained from tapping pine trees and tall oil is a resinous by-product of the kraft paper industry, and also of pine tree origin.

Work is also going forward on development of various test methods applicable to rosin such as optical rotation, identification of rosin acid components, and hardness or penetration.

Objectives in the development of improved floor wax are high gloss, ease of application, durability, ease of removal, and resistance to slip. Determination of slip resistance has been a difficult problem for the committee, for a really adequate test should correlate with the tendency for a person to slip on a freshly waxed floor. The Committee on Wax Polishes and Related Materials has expended considerable effort in the development of methods for slip resistance and is at present engaged in development of a ground glass surface for use as a secondary standard with slip-resistance testers. Other methods under intensive development are for evaluation of dirt retention, spot resistance, and wax application. Methods under study include those for viscosity, stability, and flash point. Newly accepted are tests for acid number and saponification number of natural waxes (D 1386 and D 1387).

The committee on Cellulose and Cellulose Derivatives has been closely allied with the cellulose division of the American Chemical Society and usually meets in conjunction with that group. At recent meetings, the committee has been concerned with development of a method for assaying the purity of sodium carboxymethyl-cellulose, methods for degree of substitution, viscosity, sodium chloride content, sodium glycolate content, and sodium phosphate content. Methods under development for cellulose include cold alkali solubility, nondilution alkali solubility, determination of pentosans, and residue on ashing of cellulose. Methods recently approved for publication include tests for methylcellulose (D 1347) and test for moisture in cellulose (D 1348).

Brightening Agents for Whiter Washes

The Committee on Soaps and Other Detergents has developed two new tentatives: Methods of Sampling and Analysis of Sodium Triphosphate (D 501) and Method of Aerated Total Immersion Corrosion Test for Metal Cleaners (D 1374).

The purveyors of soaps and detergents have recently been emphasizing whiter washes which can be obtained with some of the new materials. The basis for these claims is the development of brightening agents incorporated in the detergents which have the ability to absorb ultraviolet radiation and re-radiate it in the visible spectrum. Considerable information on these brightening agents is available in the literature, and the committee has compiled from the literature a Special Technical Publication entitled Bibliographical Abstracts on Evaluations of Brightening Agents For Detergent Usage (*STP 177*).

A matter of interest to those concerned with soaps and detergents as well as floor waxes and related materials is the recent action of the American Standards Assn. to establish a new Sectional Committee on Cleaning and Maintenance Supplies under sponsorship of the American Hotel Assn. The objectives of this committee are to establish performance standards for these materials. It is expected that the sectional committee will draw heavily from the ASTM standards, particularly test methods.

Water and Air

Nuclear Application Stressed

The outstanding event of interest in the field of industrial water was a symposium on high-purity water corrosion presented at the Annual Meeting. The symposium was of special interest at this time because of the current importance of the use of high-purity water in nuclear reactors. The committee has made outstanding advances in this area, and the published proceedings of the symposium will serve as a useful reference to engineers concerned with the design of nuclear reactors.

Several other groups develop standard methods for examination of water, and in order to promote uniformity in the standards, developed by the various agencies, steps are being taken toward the formation of an inter-society joint committee on uniformity of methods of water examination.

The committee presented for publication a new Tentative Method of Test for Hydrazine in Industrial Water (D 1385). The method is based on a color reaction of hydrazine with para-dimethylaminobenzaldehyde.

ASTM contributions toward control of air pollution originate in Committee D-22 on Methods of Atmospheric Sampling and Analysis. During 1955, the committee approved for publication four tentatives—a recommended practice for planning the sampling of the atmosphere, definitions of terms, a method for determining concentration of odorous vapors, and continuous analysis and automatic recording of the sulfur dioxide content of the atmosphere. The committee is currently actively engaged in the development of methods for determining various constituents in vegetation and biological materials absorbed from air containing various pollutants such as fluorides.

There is currently a great deal of interest in industry in the developments of this committee, since air pollution control is a very live subject and the availability of standards can contribute materially to control of pollution.

Fuels

The society's work on standards for gaseous fuels including the widely used liquefied petroleum gas (LPG) is under Committee D-3 on Gaseous Fuels. Jointly with Committee D-2 on Petroleum Products, Committee D-3 adopted as standard, a method of sampling liquefied petroleum gases (D 1265).

The activities of this committee are of special interest because of the rapid growth in the use of gaseous fuels in recent years. Since products of combustion of gaseous fuels generally contain a minimum of air pollution constituents, the use of fuel gas is favored in many areas for this reason.

A major development of the committee during the year was completion of a

revision of the Standard Method of Test for Calorific Value of Gaseous Fuels by the Water-Flow Calorimeter (D 900-48). This is a very important standard because the test gives the heating value which forms the basis for the unit price per cubic foot of gaseous fuels.

Following the 1954 Symposium on Coal Sampling, there has been intensive activity in Committee D-5 on Coal and Coke toward the development of more rapid and simplified methods for sampling coal based on a new statistical approach. The committee has established a research project on this subject.

Many of the projects concerned with coal and coke have international implications, and the committee is actively participating in the discussions of ISO 27 on Solid Mineral Fuels and is also actively cooperating with the coal committee of the Economic Commission for Europe in the development of a dilatometer method for use with the standard Specification for Classification of Coals by Rank (D 388). Comparative determinations of volatile matter are being carried out using the ASTM Standard Method, several modified procedures, and methods developed by the British and French.

Cellular Materials

A number of the technical committees have an interest in cellular materials such as foamed plastics and foam and sponge rubber. Committee D-11 on Rubber is actively working in this field and has developed standards for foam and sponge rubber, and that work is being extended to cover synthetic materials with rubbery characteristics. Committee D-10 on Shipping Containers is concerned with these materials for interior packing. Committee D-16 on Thermal Insulation is interested in the insulating characteristics of these materials, Committee D-19 on Structural Sandwich Construction is concerned with cellular materials as cores for sandwich structures, and Committee D-20 on Plastics is also concerned, particularly, from the point of view of the base material and with a special interest in the rigid cellular materials. Committee D-9 on Electrical Insulating Materials is concerned with the dielectric properties of cellular materials. As a result of this community of interest and because of the fast growing and important cellular materials industry, there was established during the year, the Coordinating Committee on Cellular Materials which will represent all the ASTM interests. Also represented is the Society of the Plastics Industry. The committee will facilitate the exchange of information between the various groups concerned with cellular materials. Chairman of the committee is W. A. Zinzow.

GENERAL TESTING METHODS

Common interests of all the technical committees with regard to methods of testing are centered in Committee E-1. Committee E-1 sponsored two symposia at the Annual Meeting: one on impact testing and the other on the effect of speed of testing of nonmetals. In planning stages for the 1956 annual meeting are three symposia concerning pH measurements, tension testing of nonmetals and viscosity, the symposium on viscosity to be sponsored jointly by the Society of Rheology. Development of standards for laboratory balances and thermocouples for use in pyrometry is being undertaken by task groups. Another important new activity of Committee E-1 is concerned with the standardization aspects of microchemical apparatus. This was formerly handled by a group within the American Chemical Society but because of the recently stated standardization policy of the ACS, this activity has been transferred to ASTM. Many of the same people who were concerned with this problem in the ACS will continue to work, but with the ASTM committee.

Several new and revised methods have been issued by Committee E-1 during the past year and these include a new Tentative Method for Hardness by Portable Testers (E 110) and a new Tentative Method Test for Determining Young's Modulus at Room Temperature (E 111). Six new specifications for thermometers used in methods for octane rating of motor fuels have been issued as tentative and published in ASTM Specifications for Thermometers E-1. The Specification for Hydrometers (E 100) has been revised to include 27 new general-purpose specific gravity hydrometers covering the range 0.654 to 2.005, in 0.001 subdivisions accurate to 0.001.

The knotty problems having to do with sampling, quality control, statistics, design of experiments, and similar general problems related to materials testing are handled by Committee E-11 on Quality Control of Materials. The committee has in draft form a report entitled, "Choice of Sample Size to Estimate the Average Quality of a Lot or Process." The purpose of this report is to show some simple methods by which to calculate the number of units to be included in a sample so as to estimate with a prescribed precision the average of some characteristic for all the units of a lot of material, or the average produced by a process.

Design of experiments is a subject of considerable interest to the ASTM technical committees. By proper advance planning before running round-robin and other inter-laboratory tests, a maximum amount of information can be obtained from a minimum of laboratory experiments. The committee has for some time been concerned with the development of a guide for the technical committees for the design of experiments. A paper on design of experiments prepared by W. J. Youden, chairman of the task group on this subject, has been reviewed by the committee and it is intended that the paper be published by the Society, possibly in the ASTM BULLETIN for the information of the technical committees. Following further comment and criticism the material might be published as a recommended practice.

Closely related to the work on design of experiments is a proposed tentative recommended practice covering recommendations on planning inter-laboratory test programs. This is in final draft form and may be issued in the near future as an ASTM tentative.

Task groups under Committee E-11 are actively studying the practical limits of uncertainty that may arise from sampling and the problem of smoothing empirical data.

Appearance of engineering materials includes such aspects as color, gloss, opacity, and texture. A report on the status of the work of Committee E-12 on Appearance may be found in the December 1955 ASTM BULLETIN, page 27, under the by-line of George Ingle and Richard S. Hunter, Vice-Chairman and Secretary of the committee, respectively.

Isotopes Offer Unique Opportunities in Testing

With ever-increasing emphasis on peaceful uses of the atom, Committee E-10 on Radioactive Isotopes occupies a key position in ASTM. Established to promote the use of radioactive isotopes in materials testing, the committee has been active in bringing to the attention and assisting in various ways other technical committees of the Society in the development of test methods utilizing the unique properties of isotopes. Specific tasks in which the committee is engaged include development of a procedure for determination of naphthalene in coal tar, procedures for the use of isotopes for

wear testing, detergency and soil analyses and other analytical procedures based on the use of isotopes.

The method of operation of the committee is to establish task groups in cooperation with other technical committees of the Society. While a number of technical papers concerned with the use of radioactive isotopes in the testing of materials have appeared in the technical press, including the ASTM BULLETIN, there are as yet no methods on the ASTM books. Methods based on isotopes are capable of very high sensitivity and offer unusual opportunities to many of the ASTM committees for the development of worthwhile new methods. Members of other ASTM committees who feel that radioactive isotopes might be used to advantage in testing the materials in which they are interested are urged to get in touch with the officers of Committee E-10 who will cheerfully offer assistance.

Useful Analytical Tools—Spectroscopy

A very potent tool for analysis of organic compounds which has come into wide use is that of absorption spectroscopy. Committee E-13 on Absorption Spectroscopy has added to its IBM card index to infrared spectra and the total now stands at 10,969 cards. An IBM card index to ultraviolet spectra is also available and the original 1284 card index has been expanded by the publication of a 3916-card supplement. The committee has also sponsored the publication of a 13,899-card compound name–formula IBM card index to infrared spectra. By the use of these card indexes to infrared and ultraviolet spectra it is possible to select a card by machine having the spectrum distribution of absorption corresponding to that of an unknown compound, thus providing industry both with a tool for research and with a means of rapid analysis for use in production.

Committee E-14 on Mass Spectrometry is primarily concerned with promotion of the science of mass spectrometry through the holding of scientific papers sessions. Approximately seventy papers on mass spectrometry were presented at the meeting of the committee held last May in San Francisco.

Mass spectrometry is another useful tool for analysis, and there are currently on the books, several methods using mass spectrometry for analysis of constituents of gaseous fuels developed by Committee D-3 on Gaseous Fuels. Committee D-22 on Atmospheric Sampling and Analysis has been considering the possibility of developing standard mass spectrometry methods for analysis of constituents in the atmosphere.

ELECTRICAL MATERIALS

Symposium and Round Table Discussions Set Base Line for Standardization

A symposium on electrode systems for dielectric measurements sponsored by Committee D-9 on Electrical Insulating Materials served to bring together the experiences many people have had with the ASTM method for dielectric constant and loss. Abstracts of papers presented at this symposium were printed and a few copies are still available for distribution to those interested. Information presented at this symposium added to the understanding of the significance of this test and also pointed out some of the pitfalls which are often encountered in carrying out the tests.

A round table on dielectric breakdown of insulating oils and a Symposium on Corona were also featured at 1955 meetings. The importance of corona testing is increasing especially because of higher voltages that are being used for power transmission. The exchange of ideas at the corona symposium and the availability of printed proceedings will provide a point of departure for the development of suitable test methods for the effect of corona on insulating materials.

At the fall meeting, it was decided that a new activity would be established to develop test methods for magnet wire insulation. This activity will be fully coordinated with Sectional Committee C9 on Magnet Wire operating under the procedures of the American Standard Assn.

In recent months there has been renewed interest in electrical ceramics and liaison with the Committee C-21 on Ceramics has been established, particularly with respect to development of standards for titanates and zirconates which are used for capacitor dielectrics and piezoelectric transducers.

Outstanding developments in recent years in improved electrical insulating materials, particularly, for operation at high temperatures has focused attention on the shortcomings of the present method of thermal classification of insulating materials based on definitions of the materials which fit into each class. The old definitions no longer hold for many new materials, and at the present time there is intense activity within the American Institute of Electric Engineers to establish classifications based on performance rather than on definitions. Committee D-9 has long been concerned with the properties of insulating materials over a range of temperatures, and the committee has renewed its efforts toward the development of satisfactory test methods which can be used as a basis for a new system of classification being developed by the AIEE. This interest in thermal capability also extends to the International Electrotechnical Commission in which U.S. interests are well represented.

Sectional Committee C59 on Electrical Insulating Materials has processed a number of ASTM Standards for approval as American Standards.

First of New Series of Committees Based on Materials for Specific Applications

Materials considered by the new Committee F-1 on Materials for Electron Tubes and Semiconductor Devices cut across all the technical committees of the Society; for example, various alloys of steel are used in electron tubes for a number of purposes. Also used in electron tubes are nonferrous metals, ceramic and mica insulation, and glass. Organic materials such as plastics are used also for such applications as tube bases. With this across-the-board interest in materials of Committee F-1, liaison is being established with other technical committees of the Society having an interest in the same materials.

For a number of years the Society has been engaged in the development of standards for electron-tube materials, this activity having been centered in a subcommittee in the B group of Committees (B-4 Sub. VIII). During 1955, plans were completed and organization effected of the new Committee F-1 on Materials for Electron Tubes and Semiconductor Devices. The new committee continues the previous work on electron tube materials and has added two new responsibilities—development of standards for luminescent materials and for semiconductor materials which go into transistors and other similar devices. The big use for luminescent materials is in the coating which forms the image on the picture tube used in television sets and similar tubes for radar. The work in this new activity should assist materially in production of more uniform and reproducible picture tubes and other cathode-ray tubes. Work in the semiconductor group is going forward toward development of standards initially for germanium oxide and germanium metal.

Committee Week in Buffalo—February 27–March 2

35 Technical Committees Meet; Coated Platings Symposium Planned

Thirty-five of the Society's technical committees will hold meetings of their main and subgroups during ASTM Committee Week in Buffalo, N. Y., February 27–March 2.

On Wednesday, February 29, a two-session symposium on plated coatings, to which all are invited, will be held, and Tuesday night is set aside for the customary social break of this busy week.

Room Reservations

Hotel reservation forms will go into the mails shortly to all members and committee members. Those who expect to come to Buffalo are urged to return this form as promptly as possible in order to obtain the accommodations they desire. To assist members in making their reservations, a tentative schedule of the meetings will be sent along with the reservation form.

Committee Meetings

Members of technical committees will be advised by their officers of the details of time of their meetings in Buffalo. Final arrangements for attending the meeting should be based on these official notices from committee officers. At this writing the following committees have indicated that they will convene during Committee Week:

A-3 on Cast Iron
A-5 on Corrosion of Iron and Steel
A-7 on Malleable-Iron Castings
A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys
B-3 on Corrosion of Non-Ferrous Metals and Alloys
B-6 on Die-Cast Metals and Alloys
B-7 on Light Metals and Alloys, Cast and Wrought
B-8 on Electrodeposited Metallic Coatings
C-3 on Chemical-Resistant Mortars
C-7 on Lime
C-8 on Refractories
C-11 on Gypsum
C-12 on Mortars for Unit Masonry
C-15 on Manufactured Masonry Units
C-16 on Thermal Insulating Materials
C-22 on Porcelain Enamel
D-1 on Paint, Varnish, Lacquer and Related Products
D-4 on Road and Paving Materials
D-5 on Coal and Coke
D-8 on Bituminous Waterproofing and Roofing Materials
D-11 on Rubber and Rubber-Like Materials
D-16 on Industrial Aromatic Hydrocarbons and Related Materials
D-21 on Wax Polishes and Related Materials
D-22 on Methods of Atmospheric Sampling and Analysis
E-1 on Methods of Testing—Subcommittees
E-4 on Metallography
E-5 on Fire Tests of Materials and Construction
E-6 on Methods of Testing Building Constructions
E-7 on Nondestructive Testing
E-9 on Fatigue
E-10 on Radioactive Isotopes

Technical Symposium

The Symposium on Properties, Tests and Performance of Electrodeposited Metallic Coatings, sponsored by Committee B-8 on Electrodeposited Metallic Coatings, will be held in a morning and afternoon session on Wednesday. The eight papers comprising the two sessions will cover a variety of subjects including a summation of performance data obtained from testing various combinations of copper-nickel-chromium, also lead, cadmium, and zinc coatings and chemical conversion coatings of the latter metals.

The papers will also give consideration to such matters as metal cleaning procedures, evaluation of the salt-spray test method, and work related to certain physical properties of plated coatings.

Titles and authors of the symposium papers are as follows:

Introduction by Symposium Chairman W. L. Pinner, Houdaille-Hershey Corp.
History of ASTM Committee B-8 by William Blum, formerly National Bureau of Standards
Corrosion Behavior and Protective Value of Decorative Copper-Nickel-Chromium and Nickel-Chromium Coatings on Steel by C. H. Sample, International Nickel Co.
Evaluation of Methods Available for Measurement of Surface Luster in Plated Coatings by Glade Bowman, Rockwell Spring and Axle Co.
Metal Cleaning Prior to Electroplating by S. Spring, Pennsylvania Salt Manufacturing Co.
Comparison of the Corrosion Behavior and Protective Value of Electrodeposited Zinc and Cadmium Coatings on Steel by C. H. Sample and R. B. Tell, International Nickel Co., and A. Mendizza, Bell Telephone Laboratories.
Evaluation of Supplementary Conversion Coatings on Zinc and Cadmium by R. E. Harr, Western Electric Co.
Atmospheric Exposure of Electroplated Lead Coatings on Steel by A. H. DuRose, Harshaw Chemical Co.
The Standard Salt-Spray Test—Is It a Valid Acceptance Test? by A. Mendizza, Bell Telephone Labs.

Ample time for discussion of each paper will be allowed.

President's Reception

Arrangements are being made by the Northern New York-Ontario District, who will be hosts for this meeting, for the social event of the week on Tuesday evening—a reception by ASTM President C. H. Fellows, and a dinner at which Mr. Fellows will speak. A feature of the evening will be a color film and discussion on racing. Dinner will be preceded by a Dutch-treat cocktail party.

Plan now to arrange your stay in Buffalo to include this pleasant interlude.

Papers Committee Meets in February

THE Administrative Committee on Papers and Publications will meet February 20 at which time consideration will be given to the development of the program for the Annual Meeting in June. Quite a number of formal symposiums are in prospect as indicated above, and in addition the Papers Committee has a number of offers that have been submitted individually. While all offers were to be in the hands of the Papers Committee by January 10, any significant contribution which has not been brought to the attention of the Papers Committee should be submitted immediately. It could be that consideration still can be given to such offers.

NEW ASTM PUBLICATIONS

1955 Book of ASTM Standards—Three More Parts Available

THREE more Parts of the huge 1955 Book of ASTM Standards are now off press: *Part 2*—Non-Ferrous Metals; *Part 4*—Paint, Naval Stores, Wood, Fire Tests, Sandwich Construction, and Building Constructions; *Part 5*—Fuels, Petroleum, Aromatic Hydrocarbons, and Engine Antifreezes.

Including *Part 1*—Ferrous Metals, which appeared in November, and *Part 3*—Cement, Concrete, Ceramics, Thermal Insulation, Road Materials, Waterproofing, and Soils, which appeared in December, five of the seven Parts are now available. The remaining two Parts will appear within the next few weeks.

1955 BOOK OF STANDARDS PRICES

	*Members for Extra Copies**	*Nonmembers*
Part 1 Ferrous Metals	$10.00	$13.50
Part 2 Non-Ferrous Metals	8.50	11.00
Part 3 Cement, Concrete, Ceramics, Thermal Insulation, Road Materials, Waterproofing, and Soils	10.00	13.50
Part 4 Paint, Naval Stores, Wood, Fire Tests, Sandwich Constructions, Building Constructions	8.50	11.00
Part 5 Fuels, Petroleum, Aromatic Hydrocarbons, and Engine Antifreezes	8.50	11.00
Part 6 Electrical Insulation, Electronic Materials, Plastics, Rubber	9.00	13.00
Part 7 Textiles, Soap, Water, Paper, Adhesives, and Shipping Containers	8.50	11.00
Complete Set	63.00	84.00

* Each member gets one selected Part with Supplements on his membership and can procure the other Parts and Supplements thereto at an annual charge of $3 per Part.

Bibliographical Abstracts on Redeposition of Soil on Cotton Fabric

THIS bibliography, prepared by a task group consisting of M. G. Kramer, chairman, Howard Paitchel, and W. A. Tidridge of Subcommittee T5 on Physical Testing of ASTM Committee D-12 on Soaps and Other Detergents, is the first step toward development of a suitable redeposition method.

Patterned after Committee D-12's "Metal Cleaning Bibliographical Abstracts," the references are numbered consecutively and are listed by year and then by author. The abstracts in many cases were prepared from the original article and are slanted generally toward giving an indication of the contents pertinent to testing methods and theories. Reference is made to abstracts appearing in *Chemical Abstracts* wherever possible.

The bibliography is preceded by a "Review of Literature on Theory and Practice of Redeposition Methods" which was presented at a meeting of Committee D-12 in March, 1955. It represents a consolidation of the more pertinent information developed in the preparation of the bibliography.

This bibliography, issued as *ASTM Special Technical Publication No. 173*, can be obtained from ASTM Headquarters, 1916 Race St., Philadelphia, Pa. Price: $1; to members, 75 cents.

Standards on Bituminous Materials for Highway Construction, Waterproofing, and Roofing

THE VARIOUS ASTM standard and tentative specifications, test methods, recommended practices, and definitions of terms pertaining to bituminous materials used in highway construction and in waterproofing and roofing, are all grouped together in this compilation.

This fifth edition is sponsored jointly by Committee D-4 on Road and Paving Materials and Committee D-8 on Bituminous Waterproofing and Roofing Materials. Included in this compilation are those standards covering creosote materials which are under the jurisdiction of Committee D-7 on Wood, but of direct interest to the construction field. A companion book covers mineral aggregates, concrete, and nonbituminous highway materials.

There are about 112 specifications, methods of testing, recommended practices and definitions of terms included in their latest approved form. One Appendix is also included in this compilation, namely, Stripping Test for Bitumen-Aggregate Mixtures.

Copies of this 450-page compilation, in heavy paper cover, can be obtained from ASTM Headquarters, 1916 Race St., Philadelphia, Pa. Price: $4.25; to members, $3.25.

Scientific and Technical Societies of the United States and Canada

Nat. Academy of Sciences, Washington, D.C.; 447 pp.; $7.50

THE National Academy of Sciences-National Research Council has recently published the 6th edition of this title. The increasing importance of science and technology is reflected in the number of new scientific and technical organizations listed. Some groups are concerned with specialties and are small in membership but the fact of their establishment makes them worth recording.

In this edition entries are limited to membership group organizations, and accordingly the word "Institutions" has been omitted from the title; other categories, including trade associations with research activities which were previously included, have been eliminated.

Two National Meetings in '56 Provide Huge ASTM Technical Program

With an extra ASTM meeting scheduled in 1956—the Second Pacific Area National Meeting—the Society's technical program will reach an all-time high in number of technical symposiums, sessions, and papers of general interest.

At this writing eight formal symposia are planned for the Annual Meeting and fifteen for the West Coast program in addition to at least a dozen other technical sessions divided between the two.

ANNUAL MEETING

ATLANTIC CITY—JUNE 18–22

Typical of ASTM Annual Meetings in breadth of scope and variety are the eight symposia which are in preparation within a substantial cross-section of the Society's working committees. More detailed information on the individual papers comprising these symposiums will appear in subsequent BULLETINS prior to publication, in April, of the complete program. Papers which will be presented apart from symposiums will be grouped into sessions of related material as the program develops.

Titles of the symposiums will give an idea of the work in progress, as follows:

Rheology
pH Measurement
Tension Testing of Non-Metallic Materials
Solder
In Place Shear Testing of Foundation Soil by the Vane Method
Specific Gravity of Bituminous Coated Aggregates
Ion Exchange Resins and Chromatography
Steam Testing

Engineers and technicians who attend the Second Pacific Area National Meeting will be interested in the remarkable Los Angeles Freeway System shown in partial view at right. Los Angeles' Civic Center is at upper right. . . . can be seen from the accompanying description of the technical program of the meeting, the special sessions, particularly, will have a great deal to offer highway research and materials men.

PACIFIC AREA MEETING LOS ANGELES—SEPTEMBER 16–22, 1956

Marking the Society's second national meeting on the West Coast is a tremendous technical program developing under the direction of a vigorous program committee. The 26 symposiums and sessions shaping up will make this one of the biggest and most productive meetings ever held under ASTM auspices.

Providing an extraordinary coverage of the Society's vast range of materials and testing work, the West Coast sessions will have something to offer every engineer and technician who attends.

As this BULLETIN goes to press the symposiums and sessions scheduled are as follows:

Symposiums:

Railroad Materials—Diesel Fuels and Lubricants; and Cleaning Materials
Lubricants—Analysis—Spectrographic Analysis of Lubricating Oils
Titanium—Stressing Testing Problems
Properties, Tests and Performance of Electrodeposited Metallic Coatings (1956 Spring Meeting Symposium plus special papers)
Structural Sandwich Constructions
Full-Scale Tests on House Structures
Industrial Finishes
Turbine Oils
Vapor Phase Oxidation of Gasoline
Wood Poles
Design for Seismic and Shock Loading
Developments in Glued-Laminated and Other Wood Constructions
Wood for Marine Uses and Its Protection from Marine Borers
Industrial Water
Nondestructive Testing
Radioactive Isotopes

Special Sessions:

Newer Facts About an Older Metal—Copper
Research in Materials
Cement
Concrete
Masonry Materials
Bituminous Roofing and Waterproofing Materials
Road and Paving Materials
Soils
Plastics
Fatigue

ASTM Bulletin

JANUARY 1956

NO. 211

NINETEEN-SIXTEEN
RACE STREET
PHILADELPHIA 3, PENNA.

Why Use ASTM Standards?

ASTM specifications, definitions, and methods of test should be used as standards for engineering materials because they are **competent, unbiased, widely applicable, and authoritative.**

They are **competent** because they are based on the best commercial practice, on adequate scientific research and on sound engineering judgment. Each standard is formulated and recommended by a standing committee composed of well informed technologists on the subject in question. Their recommendations are made only after extended study and deliberation, oftentimes involving extensive experimental research on the part of commercial and scientific organizations connected with the committee membership.

ASTM standards are **unbiased** because each standing committee charged with the development or supervision of standards having a commercial bearing is made up of approximately equal representation of producing, consuming, and general interests, the latter including engineering consultants, schools, independent research institutes, governmental technical agencies. Participation of general interest members insures the development of unbiased standards based on intrinsic merit rather than commercial expediency. At the same time, the producer and consumer representation see to it that the standards are practicable and that they supply a commercial need.

ASTM standards are **widely applicable** because they are formulated by committees whose members are carefully selected from all the different industries and technical groups that have occasion to use the standards. They are the result of a broad point of view over the entire field of engineering materials and are designed to serve as wide a variety of interests as possible without sacrificing the necessary detail for specific purposes.

ASTM standards are **authoritative** because they have behind them a great Society organized 50 years ago for the specific purpose of "The promotion of knowledge of the materials of engineering and the standardization of specifications and the methods of testing." The membership of the Society is a representative cross-section of the American engineering profession in all its branches. Its position, therefore, is supported not only by its own widespread membership, but also by its close relationship with technical societies and commercial associations through common membership. General recognition of these facts has placed the ASTM in an authoritative position with respect to standards for engineering materials.

ASTM standards and specifications are published in the Book of Standards and in smaller compilations of related standards pertaining to specialized materials fields.

For news of the current publication of the huge 1955 Book of ASTM Standards, please turn to page 16.

Schedule of ASTM Meetings

This gives the latest information available at ASTM Headquarters. Direct mail notices of all district and committee meetings customarily distributed by the officers of the respective groups should be the final source of information on dates and location of meetings. This schedule does not attempt to list all meetings of smaller sections and subgroups.

Date	Group	Place
Feb. 5–10	Committee D-2 on Petroleum Products and Lubricants	Dallas, Texas (Statler-Hilton)
Feb. 10	Philadelphia District	University of Penna.
Feb. 13–15	Committee D-9 on Electrical Insulating Materials	Philadelphia, Pa. (Benj. Franklin)
Feb. 15–17	Committee D-20 on Plastics	Philadelphia, Pa. (Benj. Franklin)
Feb. 17	Committee B-4 on Metallic Materials for Electrical Heating, Electrical Resistance, and Electrical Contacts	Pittsburgh, Pa.
Feb. 19–22	Joint ASTM-TAPPI Committee on Petroleum Wax	New York, N. Y. (Commodore)
Feb. 23–24	Committee D-6 on Paper and Paper Products	New York, N. Y. (ASA Headquarters)
Feb. 27 March 2	**ASTM Committee Week**	**Buffalo, N. Y. (Statler)**
Feb. 27	Committee E-13 on Absorption Spectroscopy	Pittsburgh, Pa. (Wm. Penn)
Feb. 29	Committee E-2 on Emission Spectroscopy	Pittsburgh, Pa. (Wm. Penn)
March 8	Joint Southern California District—ASME	Los Angeles
March 13–16	Committee D-13 on Textile Materials	New York, N. Y. (Warwick)
March 19–20	Committee D-12 on Soaps and Detergents	New York, N. Y. (Park Sheraton)
April 11–12	Committee D-10 on Shipping Containers	Atlantic City, N. J. (Claridge)
April 25	Detroit District	Detroit, Mich. (Eng. Soc. Bldg.)
April 26	Pittsburgh District	Pittsburgh, Pa.
April 30–May 1	Committee C-20 on Acoustical Materials	Philadelphia, Pa. (ASTM Headquarters)

J. W. Caum and L. C. Gilbert Appointed Senior Assistant Technical Secretaries

ANNOUNCEMENT is made of the appointment effective January 3 of J. W. Caum and L. C. Gilbert, formerly Assistant Technical Secretaries, as Senior Assistant Technical Secretaries. This action by the Board of Directors recognizes the excellent work which each man has been doing in his respective contacts with numerous technical committees and in other technical matters.

Mr. Caum, a metallurgical engineer, has been responsible for our Staff contacts with many of the ferrous and nonferrous metals committees, has served for several years as Staff Assistant of Committee A-1 on Steel, follows closely the work of the Joint Committees on X-ray Diffraction and the Boiler Code Committee.

Mr. Gilbert, a civil engineer, has for many years been responsible for the Staff contacts with many committees in the "C" and "D" groups, especially those concerned with constructional and related materials. He has a long list of committees, but also has handled other important assignments.

It is not expected that these promotions will alter the present Staff contacts with our more than 70 committees, but eventually some reassignments may be made as the Society's work grows.

Mr. and Mrs. Caum have three children all now in elementary school, while the two sons of Mr. and Mrs. Gilbert are through college, one working in Michigan in the wood products industry, the other in military service.

John R. Dwyer Retires

RECOGNITION was given to John R. Dwyer at the fall meeting of Committee C-1 on Cement held in Montreal on October 4. Through his long service with the committee, he has been affectionately called Mr. Committee C-1. Because of his pending retirement from the National Bureau of Standards, John is now terminating his duties with the committee as Technical Assistant and also his work as Head of the Cement Reference Laboratory at the Bureau.

The contributions made by John Dwyer to the Society, and to Committee C-1 in particular, date back more than 35 years to 1920 when he joined the Society. Through an arrangement with Committee C-1, his time has been divided between the work of the Cement Reference Laboratory and that of the committee as a part-time member of the ASTM staff. In 1954, the Cement Reference Laboratory celebrated its 25th anniversary, which also represented 25 years of service for John Dwyer as Head of the Laboratory. The prestige and standing of the CRL in the cement industry today reflects his faithful and efficient performance in this position.

John will continue to be connected with the activities of Committee C-1, which has conferred upon him an honorary membership. He will serve in an advisory capacity for a period of time with the Cement Reference Laboratory.

Mildred Odiorne Joins 25-Year Staff Group

ON NOVEMBER 18, Mildred Odiorne, longtime Secretary to R. J. Painter, serving when he was Assistant Secretary and continuing to be responsible for various secretarial matters when he became Executive Secretary, completed twenty-five years of service on the ASTM Staff. On Monday, November 7, she was the guest of honor at a dinner held at the Hotel Belgravia, with some fifty Staff members present in appreciation of her many years of loyal service. The Board of Directors remembered her with a gift of a camera, film, slide viewer, and the customary extra week's vacation for 1955.

Miss Odiorne

These occasions always produce hidden talent in the ASTM Staff in the form of poets, speakers, or dramatists, and there were several interesting examples during the evening, including some compositions by three of Miss Odiorne's companions on a European trip which they completed in October. She showed a deftness in cutting her anniversary cake and responded appropriately to the good wishes of her associates.

Miss Odiorne was born in Narberth, Pa., a Philadelphia suburb, and now lives in Wynnewood. She attended Lower Merion High School and then took a two-year secretarial course at Drexel Institute. She started on a "temporary" basis at ASTM Headquarters, then in the Engineers Club. Some of her responsibilities have included secretarial work in connection with the ASTM Exhibit, promotion for our varied publications including the preparation of sales prospectuses, work with the Developmental Committee of the Board of Directors, and a miscellaneous group of activities for the Executive Secretary involving ASTM administration. She is known by a large number of members and committee members because of her work and attendance at Annual Meetings and Exhibits.

ALLAN W. DOW

1865–1955

WITH the passing of Allan W. Dow, Consulting Paving Engineer, New York City and Bridgewater, Conn., December 8, 1955, in his ninetieth year, ASTM loses its last individual member who joined in 1898, the Society's first year. An 1888 graduate of Columbia University School of Mines, Mr. Dow was associated for some time in his early years with the Barber Asphalt Paving Co. From 1894 to 1906 he served as inspector of asphalt and cement with the Engineering Department of the District of Columbia. An outstanding pioneer and recognized authority in the roads and paving, and bituminous waterproofing materials fields, he had been engaged as a chemical engineering consultant since 1906.

Mr. Dow was largely responsible for development of test methods now recognized as important for the control of bituminous materials, of particular interest, the penetration and ductility tests, for which he devised suitable apparatus and established essential testing conditions. He had a large part in correlating the properties of asphalt cements to the design of paving mixtures and in developing requirements for grading of aggregates and composition of mixtures recognized as standard throughout the history of asphalt paving in the United States. He was among the first to suggest and supervise the laying of asphaltic concrete pavements in this country (in the District of Columbia) and to recognize the composition of gravel necessary for adequate highway surfacings. He also pioneered the early use of road oils in the East as dust layers and surface binders for roads.

In ASTM Mr. Dow was very active in a number of the technical groups. He was a Charter Member of Committee C-1 on Cement. His most notable contributions were in Committees D-4 on Road and Paving Materials and D-8 on Bituminous Waterproofing and Roofing Materials. In recognition of distinctive service to the Society in these areas he was tendered an ASTM Award of Merit in 1950.

Philadelphia District Hears Juran on Quality Control

Dr. Joseph M. Juran, Management Consultant, discussed on November 18 before an audience of more than 225 representatives of the ASTM Philadelphia District, ASQC Philadelphia Section, and the Philadelphia Section of the American Society of Women Engineers, "A Blueprint for Installing Quality Control." His talk was based on the impending competition for product quality that will be developed during the next decade. He emphasized the need that industrial enterprises broaden the means of solving complex quality problems and gave reasons why the quality problem must be considered from a broad, all-inclusive aspect if companies are to be able to rise to the task of handling the increased pressure due to quality competition.

Dr. Juran has devoted over 25 years to the problems of managerial control and has served as engineer, executive officer, and director of industry, as a Government administrator, and as a professor of management.

The technical session followed a dinner at Franklin Hall of the Franklin Institute which was attended by almost 200 members and guests of the cosponsoring societies, namely, the ASTM and ASQC.

The coffee speaker was A. O. Schaefer, Vice-President of Midvale Steel Co., ASTM Past-Director, and currently President of the American Society for Metals who was introduced by E. K. Spring, ASTM District chairman. In his address, "Importance of Standards," Mr. Schaefer mentioned the various ways that specifications are developed: individuals, companies, trade associations, Governmental Agencies, technical and professional societies where development of standards is incidental to other activities, and technical societies in which the development of standards is of primary concern.

Specifications developed by this latter group, which include organizations such as ASTM, are usually the best. In ASTM, for example, there is a balance of producers *versus* consumers and general interest members, and every attempt is made to resolve negative votes on a particular standard. In view of the diversified representation and the consideration given minority opinions, resulting specifications are widely accepted and as such are highly desirable.

Exceptionally Complete Bylaws Prepared by Committee E-2

Most of the ASTM technical committees operate under a set of bylaws or regulations which supplement the Regulations Governing Technical Committees established by the Society. Such a document sets up a *modus operandi* for governing the internal organization and procedure of committee, and particularly subcommittee, operation. Suggested forms of bylaws have been furnished to committees by Society Headquarters.

During the past year an exceptionally complete set of bylaws has been prepared under the supervision of K. O. Stevenson of the Aluminum Company of America for Committee E-2 on Emission Spectroscopy.

In addition to the usual articles and sections, the bylaws contain several additional items which are considered pertinent and which help to give more complete coverage. Such usual sections as Membership, Duties of Officers, and Subcommittees are much more complete and specific than in most bylaws. New articles and sections covering Methods and Revisions, Reports and Correspondence, and Voting and Letter Ballots explain procedures to be followed by subcommittees in the development of standards and in the conduct of subcommittee and committee business relating thereto.

Supplements to these bylaws contain an outline of the procedure for promulgation of tentatives and standards in chart form and a rather complete Index of the contents.

STUDENT MEMBERSHIP PRIZE AWARDS — MERIT SPONSORSHIP

Each ASTM member is urged to consider this very practical way of helping the engineering student, the engineering school, and the Society.

If interested in establishing such awards at your local engineering school or alma mater, return this form, and information will be sent.

A number of ASTM members pay the cost ($2 annually) of Student Memberships which are awarded on recommendation of the faculties to worthy students at various schools.

Several of the ASTM Districts also are sponsoring the Student Membership Awards at engineering schools in their areas.

To the ASTM Committee on Membership,
1916 Race St., Philadelphia 3, Pa.

Gentlemen:

Please send me information on the establishment of STUDENT MEMBERSHIP PRIZE AWARDS.

Signed _____

Address _____

Date _____

Rules for Field Welding of Steel Storage Tanks

American Welding Society, 33 W. 39th St., New York, N. Y.; $1

For the first time, the use of premium steels and provisions for testing by the use of radiography have been included in the *Rules for Field Welding of Steel Storage Tanks*. The 1955 edition of this widely-used and recognized standard has just been issued by the AWS.

The existing Rules have been revised to cover the use of premium steels, ASTM Specifications A 131 and A 373, in those cases where (1) conditions at the site are particularly hazardous, (2) ambient temperatures are extremely low, or (3) heavy thicknesses are used.

A new Appendix has been added giving detailed procedures for testing by radiographic methods. Included in the Rules are four double-size pages of radiographic porosity standards.

Scroll of Appreciation Presented to John W. Bolton

JOHN W. BOLTON, formerly Director of Research, Lunkenheimer Co., retired in 1955. Because of his long and meritorious record of service in ASTM activities and particularly in Committee B-5 on Copper and Copper Alloys, Committee B-5 presented him with a scroll of appreciation inscribed as follows:

AN APPRECIATION

The members of Committee B-5 have heard with great regret that John W. Bolton, because of ill health, has found it necessary to resign from the American Society for Testing Materials and to relinquish all activities in the field of engineering materials.

During John Bolton's long connection with the Society, which began in 1926, he served as National Director 1951-1954; he served on Committee B-5, and many of its subcommittees: he served as First Vice Chairman of B-5, 1938-1939. He also served as Chairman of A-3 on Cast Iron, 1940-1944, and was a member of its various subcommittees. He has served on Committee A-1 on Steel, and many other ASTM Committees. He has served on the Joint (ASTM-ASME) Research Committee on the Effect of Temperature on the Properties of Metals, Data & Publication Panel, Petroleum & Chemical Panel, Steam Power Panel; and was Secretary of the Committee on Effect of Temperature on Metals. His services in all of his Society activities, as well as innumerable other professional societies, have been outstanding as a result of his forceful and intelligent leadership. John Bolton not only represented the Lunkenheimer Company as Director of the Metallurgical Research and Testing Division, but also was the representative of many other societies on ASTM Committees. He strove for, and achieved, cooperation and unification of the various professional societies.

John Bolton contributed many papers in both the ferrous and non-ferrous fields. He is the author of the well-known book, "Cast Iron." He was the recipient of the AFA National (now Hoyt) Lectureship, Penton Gold Medal for Research, and several Foreign Exchange Papers.

The members of Committee B-5 will long remember his valuable services, especially to their own committee, and to the Society generally: they extend their best wishes to him in his retirement.

For Committee B-5
George Harnden
Chairman
Vincent P. Weaver
Secretary

1st Day of May, 1955

Upon receipt of this Appreciation Mr. Bolton responded by letter as follows, in part:

Work in the Society brought both pleasure and pride. The Society has striven for and achieved unification of the interests of consumers, producers, and general interests to a degree unique among professional groups. The products of cooperation within the membership and of the Society and its committees with other engineering groups and Federal agencies affect the people of our country to a degree undreamed of by them. . . .

Standards of "quality" (with which you are most directly concerned) negate the practice of *caveat emptor*. They are among the fundamentals which enable modern industry to provide safe, uniform, and economical products. . . .

The sincerity, the honesty, the objectivity and the ability of you men made my association with you a source of real pride to me. Committee B-5 typifies what is best and strongest in the Society. The Society is fortunate in its committees. . . .

Spectrographic Standard Samples of Tool Steels

SPECTROGRAPHIC standard samples of high-speed tool steels are now available from the National Bureau of Standards. Six different tool-steel standards, carefully analyzed and certified as to composition, have been added to the list of over 500 standard samples which the Bureau distributes to analytical and research laboratories for use in controlling chemical processes and maintaining the accuracy of equipment. Designed for calibrating and checking spectrographic methods of analysis, the new standards are complex alloys of iron, chromium, vanadium, molybdenum, tungsten, and cobalt, together with small amounts of other elements.

The tool-steel samples are in two forms: rod $\frac{7}{32}$ in. in diameter and 4 in. long, and rod $\frac{1}{2}$ in. in diameter and 2 in. long. The surfaces of the rods are finished by centerless grinding. Both forms serve as electrodes for spark excitation in spectrographic analysis.

The tool-steel standards may be obtained from the National Bureau of Standards for a fee of $8 each. A provisional certificate supplied with the standards gives average values of the analyses by the cooperating laboratories.

Friction Measurement Charts

RECORDING charts for the James Machine used with the Proposed Method of Test for Measuring the Static Coefficient of Friction of Waxed Floor Surfaces (ASTM BULLETIN, February 1954, p. 20), published as information by Committee D-21 on Wax Polishes and Related Materials, are now available. Order from the Chemical Specialties Manufacturers Assn., 50 E. 41st St., New York 17, N. Y. Price: $2 per hundred copies.

25-YEAR ASTM MEMBERS
1931–1956

In keeping with the desire of the Board of Directors to recognize longtime membership in the society, the names of those who have completed 25 years this year are recorded below.

Alabama, University of
Aldrich, Henry E.
Ames and Co., W.
Atlas Electric Devices Co.
Battelle Memorial Inst.
Buffalo and Erie County Public Library, Department of Technology
Burrell, Guy H.
California State Department of Public Works, Division of Highways
Carpenter, Arthur W.
Colorado Fuel and Iron Corp., The Wickwire Spencer Steel Division, Buffalo Plant
Connor, Clyde C.
Cooke, Maurice B.
Cross, Howard C.
Eagle Pencil Co., Inc.
Fellows, C. H.
Gardner, William Howlett
Gelder, Ralph H.
Gibbs, Frederick Hugh
Grotlisch, Victor E.
Gulf Oil Corp.
Hopkins, Giles E.
Indian Lac Research Inst.
Instituto de Ensayo de Materiales
Johns-Manville Corp.
Joseph, Carl F.
Karlsson, Hilmer
King, K. Van Ness
Lees and Sons Co., James
Levine, Harold J.
Lindhard, Sven
Mack, Pauline Beery
Macwhyte Co.
Marin, Joseph
McCurry, Frank W.
Moyer, Ralph Alton
New York City, President of Borough of Queens
New Zealand Public Relations
Orr, Robert W.
Osborne, F. H.
Phelps Dodge Refining Corp.
Phillips, Albert J.
Powell, Sheppard
Rice, Clarence W.
Robinson, W. E.
Rue, Harold P.
Scott, Walter M.
Scripture, E. W., Jr.
Southern Asbestos Co.
Storrie, William
Tanner, J. Roy
Tomkins, Frederick
Unitcast Corp.
University City, City of
Veatch, N. T., Jr.
Wallis, William B.
Western Lime and Cement Co., The

Copper Committee at Fall Meeting

Despite the tremendous damage to the copper industry in Naugatuck Valley by floods as a result of Hurricane Diane, the industry was sufficiently recovered to send its full quota of delegates to the October 24 and 25 meeting of Committee B-5 on Copper and Copper Alloys held at ASTM Headquarters. Pictured above is a group of the men attending the meetings. One of the high spots of the meeting was the presentation of a paper on "Mechanical Properties of Phosphor Bronze Strip," by G. R. Gohn and J. P. Guerard of the Bell Telephone Labs., Inc., and H. S. Freynik, Riverside Metal Co. Several years were spent in preparing specimens, running tests, and collecting voluminous data for this project. The paper will be published by ASTM as a Special Technical Publication.

Officers of Committee B-5 are at left, in the usual order: Secretary V. P. Weaver, American Brass Co., Chairman G. H. Harnden, General Electric Co.; Vice-Chairman W. D. France, Scovill Manufacturing Co. *Not Present:* Vice-Chairman William Romanoff, H. Kramer & Co. The Executive Subcommittee of Committee B-5, of which these same men are officers, acts in an advisory capacity to the American Standards Assn., which holds the Secretariat for Technical Committee 26 on Copper and Copper Alloys of the International Organization for Standardization. Messrs. France and Weaver attended the June 13, 14, and 15 meetings of Technical Committee 26 in Stockholm as American delegates at which time Mr. Weaver acted as Secretary of the meetings.

Purdue University Appointment

STATEMENT has been received from ASTM Director Kenneth B. Woods announcing the appointment of Donald S. Berry, formerly Professor of Transportation Engineering at the University of California, to the staff of the School of Civil Engineering, Purdue University, Lafayette, Ind. Dr. Berry will coordinate the academic programs at graduate and undergraduate levels in the field of transportation engineering, as well as teach graduate work in traffic engineering, highway economics, and related phases of transportation engineering. He will work also with the many graduate students employed in the Joint Highway Research Project, in the planning of their programs of graduate study in highway and transportation engineering.

Dr. Berry had been on the University of California faculty for the past seven years in a similar capacity, and prior to 1948 he served 12 years with the National Safety Council where he was Director, Traffic and Transportation Division. He has been active on many committees of the Highway Research Board, and is also a member of the National Committee on Uniform Traffic Laws and Ordinances, and a member of the National Joint Committee on Uniform Traffic Control Devices.

ACR Notes

An Investment That Pays 100 Per Cent A Year

By Frank T. Sisco[1]

SUPPOSE a stockbroker or a banker in your community should offer you an opportunity to invest in an enterprise that would pay you dividends of at least 100 per cent a year. What would your reaction be? Probably your first reaction would be to consign the offer to the wastebacket; your second would be to send such an invitation to the proper authorities as a violation of the blue-sky laws. It may surprise you, therefore, to know that there is in this country a legitimate enterprise that pays dividends of 100 to 200 per cent a year, and that almost any industry can invest and be assured of such returns for itself, and for the whole country as well. This enterprise is research, and the development of new or improved or cheaper products from this research; and it has been paying these high dividends for a long time.

These facts have recently been brought to light in an article by Raymond Ewell of the National Science Foundation in the July 18 issue of *Chemical and Engineering News*, where it is shown that over the past 25 years industry and the country have been made richer by $2500 to $5000 for every $100 spent on research and development. Ewell derived his figures by carefully estimating what our gross national product would have been in 1953 if we would not have spent what we did for research in the previous 25 years. Obviously such an estimate is somewhat speculative, but even if the errors are large, research is undoubtedly a superb investment. Practical confirmation of Ewell's figures came from several companies manufacturing chemicals and petroleum products, who estimated the returns from their investments in research and development as 160 to 200 per cent a year. There is much justification for Ewell's assumption that research is the most important single factor in the economic growth of the United States.

Research and development have grown exponentially for the last 25 years; we are now spending about $4 billion a year, or as much in one year as we spent altogether from 1776 to 1933. But even now the amount spent for research and development is only 1 per cent of the gross national product. This is a large amount compared with the 0.3 per cent spent 25 years ago, but it is still far too low to produce a healthy annual increase in the prosperity of industry and of the country.

If any reader of this page, or his company, is uncertain how to invest (and I emphasize the word *invest*) in this profitable enterprise, ASTM has a 30-year-old organization that can help him. One of the major objectives of the Administrative Committee on Research is the encouragement and stimulation of research to increase our knowledge of engineering materials, and the committee has a splendid list of 67 important unsolved problems in materials suggested by the ASTM technical committees, all of which give ample promise of paying substantial dividends if they are solved.

[1] Director, Engineering Foundation, New York, N. Y.; Member, ASTM Administrative Committee on Research.

Asphalt Fellowships at Purdue

The School of Civil Engineering and the Graduate School of Purdue University announce the availability of approximately twenty-two graduate fellowships for the summer session, June 11 to August 4, 1956. These fellowships carry a stipend of $700 and are made possible by a free grant from the Asphalt Institute.

The fellowships will be made available to selected applicants who are teachers or research personnel in Schools or Departments of Civil Engineering and who are qualified and interested in asphalt and flexible pavement technology and construction. The program of study will include regular graduate courses in bituminous materials, bituminous-aggregate mixture design, and flexible-pavement design supplemented by a weekly symposium program led by outstanding authorities in asphalt technology.

Requests for information concerning the free-grant fellowships or other summer-session programs in Civil Engineering should be addressed to Prof. K. B. Woods, Head, School of Civil Engineering, Purdue University, Lafayette, Ind.

N. Y. Chemists' Club Library

THE New York Chemists' Club Library now presents a new look to its reading public. Containing one of the country's outstanding collections of chemical literature, its recent renovation has evoked enthusiastic approval from library users.

The Priestley Room has been restored from an infrequently used museum and is open as a reading room, primarily for members. Historical exhibit pieces and a collection of old chemical works are retained in the Priestley Room and duplicate sets of important chemical reference books have been placed in special bookcases for convenience for the readers.

The Library, located at 52 E. Forty-first St. in New York City, is open to the general public during business hours to give service to the whole chemical industry. Its resources are available not only to scientists but to technical executives, market research workers, sales executives and organizations, advertising people and publishers handling technical copy as well as to those embryo chemists and chemical engineers the college and university students.

The Library has recently been designated as the official depository for the papers of both the Commercial Chemical Development Assn. and the Chemical Market Research Assn., making these publications easily available to the interested public.

ALCA and ASTM Cooperate to Develop Leather Standards

MEETING in October and again in December, a planning group representing the American Leather Chemists Assn. and ASTM and drawn from a cross-section of the leather industry, outlined final plans for the organization of a Joint Committee on Leather. This executive committee elected J. R. Kanagy of the National Bureau of Standards as its chairman; R. J. Wirshing, General Motors, vice-chairman; and M. H. Battles, A. C. Lawrence Leather Co., secretary.

Other members of the executive or advisory committee are: R. G. Ashcraft, Endicott-Johnson Corp.; A. N. Kay, Howes Leather Co.; B. L. Lewis, Tinius Olsen Testing Machine Co.; Mieth Maeser, United Shoe Machinery Co.; G. H. Meyer, Liberty Dressing Co.; R. Shaw, Rohm & Haas Co.; and J. N. Smith, E. F. Houghton & Co.

Advance planning by the executive committee included the appointment of a task group consisting of R. J. Wirshing, M. Maeser, and R. G. Ashcraft to develop a proposed scope and by-laws for consideration at the organization meeting. The committee also agreed that the following would probably be needed:

Nomenclature and Definitions
Sampling and Conditioning for Physical Testing
General Physical Testing
Research
Editorial

The committee listed a number of companies and individuals to be invited to participate in the work. These included producers and consumers of light and heavy leathers, allied trades, and others with a general interest.

The ALCA for a number of years has been actively engaged in the development of testing methods which have been closely coordinated with those of the Federal Government. The ALCA methods, which are standards for the industry, will form a basis for the initial work of the joint committee.

One of the important objectives in the establishment of the new committee is to bring together representatives of leather tanners, fabricators, users, and those with a general interest, to meet and solve problems of mutual interest. It is expected that the joint activity will result in the development of test methods which will have wide utility and acceptance in industry and commerce.

It is expected that the organization meeting of the committee will be held sometime in the spring. Those interested in having further information concerning the committee may address inquiries to the Society Headquarters.

Creep of High-Purity Nickel

ALL METALS "creep" that is, deform continuously provided temperature and stress are sufficiently high. Although this phenomenon is often observed, no universally acceptable physical theory has yet been developed for the mechanism of plastic flow in creep. The interrelation of strain hardening, recovery, and recrystallization in the process are not fully understood, and there is a need for precise data on the creep of metals and alloys under carefully controlled conditions.

As part of a long-range research program the National Bureau of Standards recently completed a study of the creep characteristics of high-purity nickel, which should be of particular interest because of the relatively low temperature at which creep occurs in this metal and the current wide use of nickel alloys in jet engines, electric heating elements, and other high-temperature applications.

The NBS investigation dealt with the creep behavior in tension of annealed specimens of high-purity nickel under constant load at 300, 700, 900, and 1200 F. The influence of rate of loading on creep behavior and the effect of strain history on the tensile properties of the nickel at room temperature were also evaluated. In addition, contour and hardness surveys were made both on specimens fractured in creep and on specimens fractured in tension at room temperature. The creep and tensile behavior of the specimens was correlated with their microstructures.

The specimens were rods with 2-in. gage lengths and 0.505-in. diameters processed from an ingot that was prepared by induction melting. In the creep studies the specimens were heated in air to the desired temperature and held at this temperature for 48 hr. Increments of load were then at intervals until the desired creep stress was reached.

Discontinuous flow was observed in each of the three stages of creep at the temperatures investigated. The discontinuities were manifested as serrations in curves of extension *versus* time and creep rate. The magnitude and frequency of these serrations were affected by such factors as temperature, stress, strain aging, strain hardening, recovery, recrystallization, grain orientation, grain rotation, formation of sub grains, and grain growth.

At 300 F the nickel had a high resistance to creep at all stresses up to 45,500 psi. However, with a further increase in stress of only 500 psi, the secondary creep rate increased by a factor of about 100,000. The phenomenon of strain aging was especially prominent at 300 F, as was

To ASTM Members: Your help is needed in maintaining that constant increase in ASTM Membership

To the ASTM Committee on Membership
1916 Race St., Philadelphia, 3, Pa.

Gentlemen:

Please send information on membership to the company or individual indicated below:

_____

_____

This company or individual is interested in the following subjects: indicate field of activity, that is, petroleum, steels, non-ferrous, etc.

_____

Signed _____

Date _____ Address _____

manifested by an appreciable creep life in some specimens loaded relatively slowly to stresses in excess of the tensile strength (46,400 psi) at this temperature.

The experimental values for primary creep agreed fairly closely with the results predicted by the theory of exhaustion and generation of dislocations as proposed by Mott and Nabarro and modified by others. However, the creep rate in the secondary and tertiary stages could not be predicted accurately by existing formulas.

Logarithmic plots of creep rate *versus* time were nearly linear in the initial portion of the first stage of creep. However, nonlinear relations were generally obtained between stress and secondary creep rate when experimental values were plotted on either a log-log or semilog (log of rate) basis. Moreover, the secondary rate was not a consistent index of the ductility of the nickel at the beginning of the tertiary stage at fracture.

The prior strain history of the nickel had a marked effect on the secondary creep rate. The Bureau's experimental results thus emphasize the importance of controlling the rate of loading in creep testing.

Relatively little information has been available on the third stage of creep. The initiation of this stage has been attributed to such factors as the beginning of microcracking, increase in creep stress due to a decrease in the area of the specimen, and atomic rearrangement. In the NBS experiments, cracks of microscopic dimensions were not found to be a prerequisite for the initiation of the third stage of creep. In all specimens tested at 300, 700, and 900 F, internal disintegration was confined to the region of complete fracture, and the fractures were preceded by appreciable necking.

Recrystallization, sometimes accompanied by grain growth, occurred in the specimens fractured in creep at 1200 F. However, no evidence of recrystallization was detected in a metallographic study of all the specimens fractured in creep at the lower temperatures. The fractures appeared to be predominantly transcrystalline at 300, 700, 900 F and intercrystalline at 1200 F.

Random Samples . . .

Shades of Davey Crockett

Color adds tremendously to television's impact by enhancing both the beauty of the scene and the viewer's sense of reality. But before color could liven the TV screen, many technical problems had to be studied and solved.

One of the difficult jobs faced by electronics engineers of the Radio Corporation of America was to control color signals supplied to the color picture tube by the receiver. This tube is the key factor in the RCA compatible color television system. It is little different in outward appearance to the layman from the millions of black-and-white picture tubes now in use in American homes in conventional monochrome receivers. However, all the color converting mechanism is contained in this single unit—the color picture tube.

In effect the color picture tube shows three fundamental primary color pictures which blend to form a single full-color impression. Instead of the single electron gun found in monochromatic picture tubes, the color tube contains three electron guns. Each gun scans the viewing screen with an electron beam: one beam carries a red signal, another carries a green signal, and the third carries a blue signal. These beams stimulate tiny phosphor dots on the viewing screen which convert the electronic radiation given off by the electron guns into different values of light. On a 21-in. color screen there are more than a million phosphor dots arranged in groups of three: a red-glowing, blue-glowing, and green-glowing dot in each group.

Colors in the visible spectrum can be electronically produced by varying hue and saturation through control of the relative brightness of the three selected colors. When all three dots in a group glow together in the proper proportion the viewer gets an impression of white. Green and red together result in yellow; red and blue give purple. Absence of all three produces an impression of black.

Control is extremely important to prevent the beam containing, say, red information from striking blue- or green-glowing phosphors. A thin shadow mask directly behind the viewing screen controls the electron beams and helps make compatible color TV possible. Thousands of tiny perforations in this mask let only the right electrons fall on each color phosphor. The result is perfect color register. The shadow mask for a 21 in. screen contains more than 350,000 holes 0.01 in. in diameter, accurate to 0.0005 in. The holes are produced by photographic printing of a dot pattern on thin cupro-nickel strip and then etching the material.

Cupro-nickel has a uniform structure which allows it to be rolled to 0.004 in. without flaws and etched with a very high degree of accuracy. Cupro-nickel is also strong and malleable. The cupro-nickel shadow mask may be formed without distorting the tiny holes. Cupro-nickel is nonmagnetic. It will not deflect the flow of electrons. And, because it has an adequate melting temperature, it does not impair the vacuum in the tube with metallic vapor.

The American Brass Co., Waterbury, Conn., developed an improved cupro-nickel alloy for application to color television. Buckbee Mears Co., photo-engravers of St. Paul, Minn., etched the tiny holes.

Inco Nickel Topics, Vol. 8, No. 9
1955, The International Nickel Co., Inc.
67 Wall St., N. Y. 5, N. Y.

To ASTM Nonmembers: The Society welcomes inquiries on the "Advantages of Membership"

To the ASTM Committee on Membership
1916 Race St., Philadelphia 3, Pa.

Gentlemen:

Please send me information on Membership in ASTM and include a membership application blank.

Signed _____

Address _____

Date _____

Trade Technical Groups and Government—Industry Standardization*

By Lester Benoit

THE DEVELOPMENT and promulgation of standards is an important part of association work. American industries are spending thousands of dollars yearly on their standardization programs, not only jointly through their industry association and in support of ASA, but within their plant operations as well. Nearly every association has a standardization division or at least a standardization committee which administers the association relationships with outside standardizing groups. It can be seen readily that "Operation Standards" ranks high on management's list. "Operation Standards" also ranks high on Government's list, as evidenced by the work of such agencies as the Standards Division of General Services Administration, the Standardization Office of the Department of Defense, and, of course, our National Bureau of Standards.

If this vast expenditure is to become as profitable an investment as it should and can be, industry and Government must use the standards developed to the fullest extent possible. Obviously, if the standard is such that it can be fully utilized by both industry and Government then the return is even greater.

The idea of industry-Government cooperation in standards is not exactly new; there has been a good measure of cooperation by representatives of the Defense and other Federal departments in the work of our national standardization groups. However, it does seem that the usage of these standards after development has been much greater on the part of industry and the commercial buyer than by the Governments at various levels—city, state, Federal.

Government Use of Commercial Standards Urged

American industry is geared to these nationally recognized standards in their production and customer relationships, while Government specifications are not so familiar—especially in the smaller companies. Industry would, therefore, like to see the greatest use possible made of commercial standards by Government.

There are, of course, many items that the Government buys for which there are no comparable commercial standards. This is especially true of the needs of the Department of Defense. No purchasing agent is ever in the market to buy a machine gun, or a 44-in. solid bronze sea valve, and in such cases, a Government specification or standard is the answer. However, in the case of the sea valve, the specification could be simplified for industry by referring to the ASTM standard for the bronze, to the American Standard for the bolts and nuts and so forth.

Roughly, 700 millions of threaded malleable iron and cast-iron pipe fittings are sold by our industry over the counter each year. The basis of these sales and production is the American Standards B16 series. In similar cases, where the item is unipartite or is a simple devise in common use, Government procurement can be on the basis of these standards. In addition, use of the national commercial standard would relieve the Government of the cost of publication and the work of keeping standards current, which is always a drain on available manpower. National standards are constantly under review by the committee in charge to reflect the latest and best practices, and using them brings the best value at any specific time.

Role of the CEOM

In the development of standards and specifications usable by both industry and Government, the trade technical groups and associations as represented by the Conference of Executives of Organization Members of ASA can play a useful part. These associations have a wealth of information on standard industry practices. The views expressed by an association or technical society are over-all industry views which are common to the industry as a whole. An over-all industry view should form the basis of a standard or specification since, in the time of emergency, our armed forces must have an entire industry behind them and not one or two producers. If industry as a whole cannot meet the standard, it is only partially effective. We have gone through two world wars without having our production facilities destroyed, but we might not always be so fortunate. Every manufacturer's facilities producing the needed item should be available. Use of common national standards will go a long way toward making this possible. In times of peace, it opens more sources of supply, creates competition, and lowers the cost to the buyer.

Army Engineers Inspection Manual—A Model

Recently the Corps of Army Engineers wrote standard inspection manuals for the use of new inspectors to familiarize them with the products they would inspect, and also, the manufacturing processes used, primarily those directly related to inspection. Through cooperation with our technical group, manuals on valves and fittings were written in industry jargon, terms were industry terms and not necessarily those of the dictionary so that the inspector would be familiar with the language of the testing and plant inspection people with whom he deals directly.

Photographs were supplied showing the basic steps in manufacture, not the details of any one maker, but photos that would give a good general knowledge of the product and how it was made and inspected—in short would really accomplish the purpose of the manuals. In this form I am sure they will be more helpful to the inspector.

The Marking Problem

When the piping difficulties occurred in the *Nautilus*, a mild wave of hysteria ran through the piping industry demanding markings. Valve manufacturers were asked to mark valves with this or that mark according to the idea of the

LESTER W. BENOIT is Executive Secretary, Manufacturers Standardization Society of the Valve and Fittings Industry, New York City, and chairman of the Conference of Executives of Organization Members of the American Standards Assn. (CEOM).

* Presented at the Sixth Annual Conference on Standards sponsored by the American Standards Assn. and the National Bureau of Standards in Washington, D.C., October 26, 1955.

person writing the letter. Obviously, to be of any value, markings must have a common meaning. To work with manufacturers individually would only produce chaos. When a problem of this kind arises, the solution is to work with the industry technical group and develop a standard not only for the markings themselves, but also to take cognizance of the feasibility of applying the mark to the product. Fortunately, this was not a problem for the valve industry. We have a standard on marking for valves, flanges, and fittings which was developed by our industry technical group and which is followed by all manufacturers.

It is in this basic type of thing that associations and technical groups can be most helpful in this effort to develop standards and specifications suitable for industry and Government alike.

Progress Encouraging

Considerable progress has been made that is worthy of mention. In the current edition of the U. S. Coast Guard Marine Engineering Regulations, materials are covered by ASTM Specifications, dimensional standards are American Standards and the ASME Unfired Pressure Vessels and Boiler Construction Codes are recognized. Previously, the Regulations were written in complete detail and in order to prevent misunderstanding and enable the industry to supply valves and fittings within the spirit and intent of the Rules, our MSS Marine Committee developed an industry interpretation booklet translating the Regulations into industry standard procedures. Since the new practice of using the commercial standards has been established, we have paid little attention to our interpretation booklet. Actually, there is now little need for it as the national standards referred to are used daily by the industry.

Proposed revisions of Federal Specifications which work in the American Standards covering the product have been received from the General Services Administration, also several proposed Federal standards for comment. A recent one on plugs, bushings, and locknuts eliminates over 400 items. This will result in a substantial saving. Our Society reviewed the standard and sees no reason why the items chosen should not take care of Government needs adequately. It will not satisfy the whims of every piping erector but most certainly enough varieties will be available to do a proper job.

Also, there is presently a good measure of cooperation between trade technical groups and the Bureau of Ships and Bureau of Yards and Docks. As stated before, reaching common ground is not so easily accomplished, but there are still areas where mutually beneficial work can be done. Industry has an obligation to make an honest effort to incorporate the points of difference in Government requirements into their standard production wherever possible—especially on items which are purchased continuously. In some areas industry is already producing to Government specification for their regular product offered the commercial user. It is hoped that this trend can advance at a healthy pace, and in this connection, we executive officers of our respective associations have a duty. It behooves us as staff men to promote the development and use of common Government-commercial standards by our industries.

Bringing the proceedings of this Sixth National Standardization Conference to the attention of the managing executives of your company members is an excellent way to do so and I recommend it. Again, if we are to receive the maximum return for the vast investment by industry and Government in standards work, we must work together in that spirit of give and take characteristic of our American method of carrying on our standardization work. In this effort the trade technical groups can play a useful role and are ready and anxious to do so.

Many Materials Matters Discussed at ASME Diamond Jubilee Annual Meeting

The highlight of the 75th Anniversary Year of The American Society of Mechanical Engineers, its Diamond Jubilee Meeting in Chicago, November 13–18, included many sessions and papers and other activities of direct concern to the field of materials as evidenced by the presence of a goodly number of ASTM members and committee members.

During the week the very active ASTM-ASME Joint Committee on Effect of Temperature on the Properties of Metals held meetings, and Thursday's Power Session dealing with metals engineering included papers on the subject of large rotor forgings for turbines and generators. A paper from Westinghouse dealing with rotor forgings stressed the importance of stability and featured a description of an interesting model test to destruction; a paper from General Electric had to do with acceptance guides for ultrasonic inspection of such forgings.

A. O. Schaefer, Vice-President, Midvale Co., and Chairman of the ASTM Steel Committee's Subcommittee VI on Steel Forgings, described the important work of a task group which for over a year has been studying intensively brittle failures in large steel forgings. He stated that the work has naturally subdivided itself into, *first*, development of a test to determine whether the steel is subject to brittle failures and its susceptibility; *second*, studies of how to make rotors less susceptible to failure by such methods as heat treatment, chemical analysis, vacuum pouring techniques, etc.; and, *third*, development of methods of inspection and of interpretation to avoid brittle failure of forgings in service. Mr. Schaefer pointed out that both the manufacturer and the user of rotor forgings have these problems under constant review with some of our best technical talent. The excellent record of the material substantiates the statement that the industry has applied the finest practices it knew. The committee has had numerous stimulat g discussions at its regular meetings; several important ideas have been brought out and action is being taken on a number of fronts.

In another session, a paper from Allis-Chalmers described the failure of a turbine shaft at Commonwealth Edison's Chicago Plant and the conclusions that were reached from exhaustive studies, including the assumption that hydrogen embrittlement had much to do with the failure.

ASTM has been officially represented at several of the outstanding ASME special meetings during the year and has extended congratulations to this great society with which ASTM is closely associated in a number of important activities. When one considers that the final program for this Diamond Jubilee Meeting itself ran 160 pages, he has some concept of the extent of the meeting and the great activity during the week.

The Bookshelf

Bearing Lubrication Analysis

R. R. Slaymaker, John Wiley and Sons, Inc., New York, 108 pp.; $5

THIS concise volume is a valuable addition to the literature on bearing design and lubrication. The treatment of the subject is aimed principally at students of machine design, the material serving as the basis for a graduate course in lubrication at Case Institute of Technology. However, Professor Slaymaker has wisely avoided much of the complex mathematics and has presented his subject in a way that will be useful to practical design and lubrication engineers.

The text considers journal bearing lubrication from the point of view of load-carrying capacity, friction, oil flow, and temperature rise. The methods of computation are carried over into bearing design, with two excellent examples to serve as models. A chapter is devoted to bearing materials, construction and life; another treats oil-less bearings and boundary conditions as encountered in bearings. The properties of lubricants are discussed briefly.

In a volume of this size, it is obviously impossible to present all the material needed to be an expert in bearing design or lubrication analysis. In this book, bearing lubrication is developed from basic theory into practical expressions that have been proven reliable. To anyone who wants to be able to design sleeve bearings or to understand their lubrication, this book is recommended.

J. C. GENIESSE

Materials of Construction

M. O. Withey and G. W. Washa; John Wiley and Sons, Inc., New York, N.Y.; 750 pp.

THE original aim of Dean J. B. Johnson in compiling his treatise on *Materials of Construction*, some 50 years ago, was to present a book to serve both as a text and as a reference book. This ideal was successfully perpetuated through eight editions, with the authors of this revised and completely new edition maintaining the same purpose and usefulness of their predecessors.

This is a well-organized book that thoroughly covers the sources, manufacture, fabrication, and testing of the principal materials of construction. The first portion of the book is somewhat of an introduction dealing with the principles of mechanics of materials, the machines and apparatus for mechanical tests, and the various testing techniques, including an entire section on nondestructive testing. The remainder of the book covers the specific construction materials such as wood, building stone, clay products, cement, lime, concrete, and ferrous and nonferrous metals.

The text is adequately illustrated with pictures, diagrams, curves, and up-to-date tables on such things as temperature effects, strength requirements, concrete mix design, alloy steels, production costs, and the like. The amount of material covered in this book is so extensive that a detailed review of all the chapters is out of the question.

The authors have incorporated into each chapter the latest information available on the properties and testing of materials. In the chapters on concrete, for example, they draw from field experience and laboratory experiments to illustrate the effects of various elements and conditions which greatly influence the properties of mortar and concrete. Results of many investigations showing the effect these factors have on the strength and elastic properties, permeability, thermal properties, and durability are clearly illustrated and tabulated. In fact, this section on concrete is an adequate treatise in itself.

In discussing the main qualifications demanded of a cement such as permanency of structure, strength, and rate of setting, the authors demonstrate the importance of physical and chemical tests. In order that results of such tests made by different parties are in accord as nearly as possible, it is necessary that standard methods be rigidly followed. Consequently, the text contains frequent references to ASTM Standards. Although the tests are not given in complete detail, adequate descriptions provide the reader with sufficient background and direction for selecting the appropriate test procedure.

The section on metals covers the field from the ores to the manufacture of iron and steel shapes. The authors point out that, "chapters on wrought iron, alloy steels, non-ferrous metals, fatigue of materials, effect of mechanical work on the properties of steel, heat treatment of steel, and effects of temperature on the properties of metals have been largely or completely rewritten."

In the concluding chapter, the authors consider fatigue of structural materials. This is not intended to serve as a complete treatise on the subject but merely to present some of the basic ideas and theories. Some of the early fatigue experiments and some of the latest theories advanced in recent times are outlined. For the student, it serves as an introduction to further study of the behavior of materials.

The authors have presented this wealth of material in masterful fashion. It would be a worthwhile text for an undergraduate course in materials, and would serve equally as well the practicing engineer who desires a ready source of information on the latest developments covering the materials of construction.

Code for Pressure Piping ASA B31.1—1955

American Society of Mechanical Engineers, 29 W. 39th St., New York, N. Y.; 84 pp.

THE NEED for a national code for pressure piping became increasingly evident from 1915 to 1925. As a result the American Standards Assn. initiated Project B31 in March, 1926 at the request of The American Society of Mechanical Engineers and with that society as sole sponsor. After several years' work by Sectional Committee B31 and its subcommittees, a first edition was published in 1935 as an American Tentative Standard Code for Pressure Piping.

A revision of the original tentative standard was begun in 1937. Several more years' effort was given to securing uniformity between sections and to eliminating divergent requirements and discrepancies as well as to keeping the code abreast of current developments in welding technique, stress computation, and reference to new dimensional and materials standards. During this period a new section was added on refrigeration piping, prepared in cooperation with the American Society of Refrigeration Engineers and complementing the American Standard Code for Mechanical Refrigeration. This work culminated in the 1942 American Standard Code for Pressure Piping.

Supplements 1 and 2 of the 1942 code, which appeared in 1944 and 1947, respectively, introduced new dimensional and material standards, a new formula for pipe wall thickness, and more comprehensive requirements for instrument and control piping. Shortly after the 1942 code was issued, procedures were established for handling inquiries that require explanation or interpretation of code requirements, and for publishing such inquiries and answers in *Mechanical Engineering* for the information of all concerned.

Continuing increases in the severity of service conditions, with concurrent developments of new materials and designs equal to meeting these higher requirements, had pointed the need by 1948 for more extensive changes in the code than could be provided by supplements alone. By that time also the then existing personnel of Sectional Committee B31 was in need of reorganization to fill vacancies and to replace those members whose interests had changed over the years.

(Continued on page 61)

An Apparatus for Measuring Air-Flow Resistance of Acoustical Materials[1]

By Hale J. Sabine

An apparatus is described for measuring the air-flow resistance of various types of acoustical materials by means of multi-range instrumentation and a flexible sample mounting arrangement.

THE air-flow resistance of an acoustical material is one of the important physical characteristics which determine its sound-absorbing efficiency. Measurements of flow resistance are therefore useful for control purposes at various stages in the manufacture of acoustical products and are also of value in basic research and product development. Tests of several different types are necessary to include the many varieties of acoustical materials that may be dealt with, as well as the successive steps in the manufacture of a specific product. A laboratory apparatus designed to perform these various types of flow-resistance tests with a maximum of flexibility and convenience is described in this paper.

Definitions

The *flow resistance* of a given specimen of material of arbitrary size or configuration is the differential static air pressure across two specified faces required to produce unit volume velocity through it. The dimensions of the specimen and the identification of the faces must be stated or understood.

The *flow resistivity* (or specific flow resistance) of a material is its resistance per unit cube in a specified direction. In nonisotropic materials, such as felted fiber boards or mats, the resistivity perpendicular to the face is in general higher than in a direction parallel to the surface. The qualifying terms *transverse* and *lateral* resistivity (or resistance), respectively, are suggested to cover these cases.

Apparatus

The general function of the apparatus described below is to produce a steady air flow through a specimen, to measure the volume rate of air flow, and to measure the pressure differential across the specimen produced by the air flow. The resistance, R, of the specimen is determined by dividing the pressure differential, P, by the volume rate of air flow, Q. Resistivity is determined from this basic measurement by including the dimensions of the specimen in the calculations, as will be explained later. Instrumentation for measuring air flow through and pressure across a specimen has been described frequently in the literature. The equipment used for these tests is basically of a conventional design, such as that described by Beranek,[2] but it incorporates several modifications which adapt it to a wider variety of tests.

The apparatus is shown schematically in Fig. 1 and is illustrated in Fig. 2. Air flow is set up through the system by the replacement of water drained from the airtight tank, *1*, causing air to flow into the specimen directly from the room. Four rotameters having ranges, respectively, of 0–0.5, 0–3.5, 0–30, and 0–120 cu cm per sec of air are placed in the line for measuring the volume rate of air flow through the specimen. These instruments indicate air flow by the height to which a ball in a tapered tube is raised by the upward flow of air. Each is equipped with a needle valve by which the air flow can be adjusted closely from zero to the full capacity of the rotameter. In operation, three of the four rotameters are closed, and air flow is measured with the one having the desired range. The air-flow line may be connected to either of the sample mounting systems, *A* or *B* (to be described later), by means of the pair of stopcocks, *3*. One of the two slant manometers, *4*, as selected by the pair of stopcocks, *5*, measures the pressure differential across the sample caused by the flow of air through it. The manometers are calibrated in inches of water and have ranges of 0–0.1 and 0–1.0 in., respectively. The manometers may be connected to either of the mounting systems, *A* or *B*, by means of the pair of stopcocks, *6*.

Types of Mounting Systems

Integrally Perforated Materials

Mounting system *A* is a special test jig assembly used only for nondestructive tests on acoustical tile that are integrally perforated with holes of uniform diameter and spacing in a square pattern. The test jig, shown in Fig. 3, is a section of 2-in. tubing (*7* in Fig. 1) mounted to move freely up and down in a perpendicular position with respect to the face of the tile. The upper end of the tube is covered with a cap containing connections to the manometers and the air-flow line. The lower end has a special specimen contactor, *8*, which is square in cross-section and designed to inclose four perforations in the face of the tile. The bottom edge of the contactor is provided with a channeled recess into which is fitted a gasket of Corogel, a soft, rubber-like material, to form an airtight seal with the surface of the specimen. The gasket is formed by melting the Corogel and pouring it into the recess. The particular contactor shown in place in Fig. 3 is designed to inclose four perforations of not over $\frac{3}{8}$-in. diameter and with spacings from $\frac{1}{4}$ to $\frac{1}{2}$ in. This range includes most of the uniform perforation patterns that are currently used in integrally perforated acoustical tile. The contactor, however, is removable and may be replaced by units designed to accommodate other

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to ASTM Headquarters, 1916 Race St., Philadelphia, 3, Pa.

[1] This paper has been prepared by Hale J. Sabine, Secretary of Subcommittee V on Basic Physical Properties of ASTM Committee C-20 on Acoustical Materials. The members of the subcommittee have recommended its publication for purposes of providing information and sounding out general interest in this type of test as a basis for drafting a tentative method.

[2] L. L. Beranek, "Acoustic Measurements," John Wiley & Sons, Inc., New York, N. Y., p. 847 (1949).

The Author. . .

H. J. SABINE, The Celotex Corp., Chicago, has been engaged since 1930 in the testing, product development, and field application of architectural acoustical materials. He is secretary of Committee C-20 on Acoustical Materials.

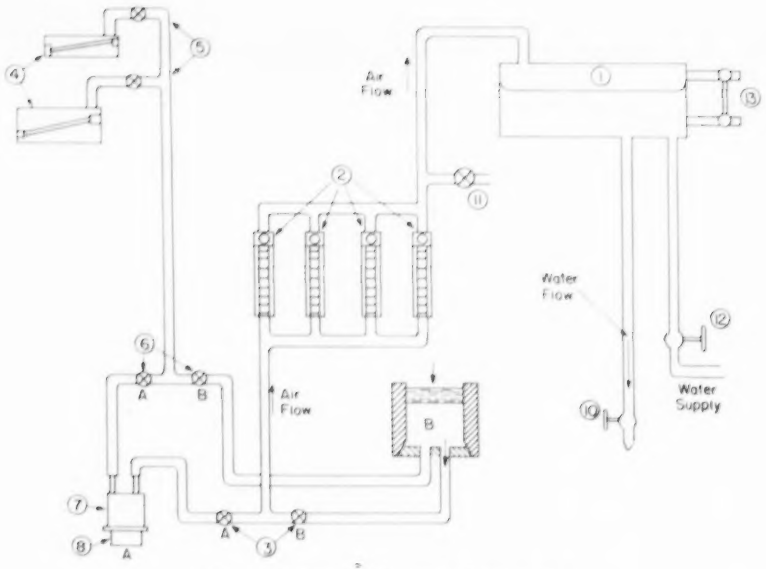

Fig. 1.—Schematic Diagram of Apparatus.

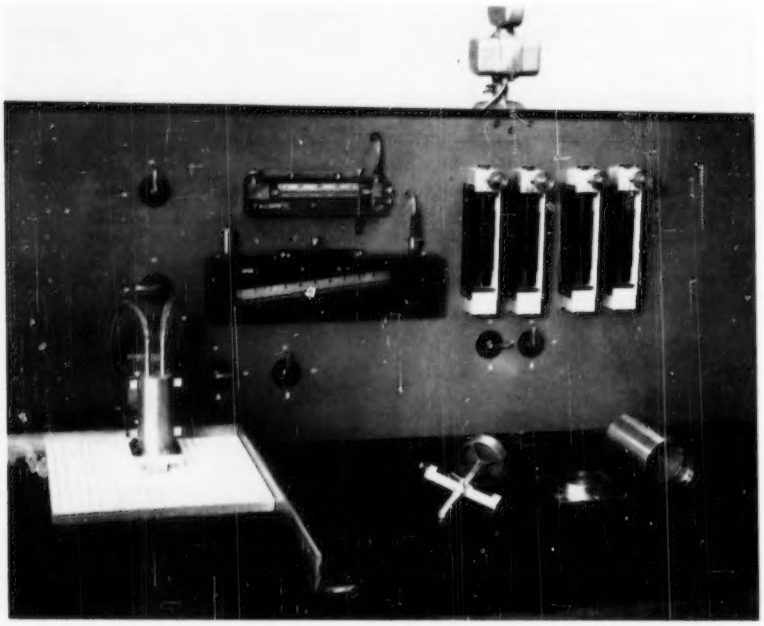

Fig. 2.—View of Instrumentation and Specimen Mountings.

patterns or to inclose a larger number of perforations if desired.

When the test jig with a 4-hole contactor is lowered onto the specimen and air flow is started, air is drawn into the perforations immediately outside of the contactor, laterally through the body of the tile, and out again through the perforations inside the contactor, as indicated in Fig. 4. It is found experimentally that unless the bottom surface of the tile is given an airtight coating, such as heavy grease, a slight amount of additional air flow takes place through the bottoms of the perforations and outside the back surface of the tile. This effect may cause inconsistent results depending on the thickness of material between the bottom of the perforation and the back of the tile, and also on the amount of air leakage between the back of the tile and the surface on which it is placed. If back leakage is made negligible, the value of flow resistance determined in the above manner will vary with the depth, diameter, and spacing of the perforations. However, if all of these factors are constant, the measured resistance will be found to correlate closely with the sound absorption coefficient of the tile for a given over-all thickness and a given sound frequency. This method of measurement is therefore especially useful as a simple control test for sound absorption of the finished product where facilities for direct sound absorption measurement are unavailable or impractical.

Homogeneous Materials

Sample mounting system *B* is designed primarily for measuring transverse and lateral resistivity of homogeneous materials. It consists of a base plate mounted permanently on the bench top, with connections to the air flow line and the manometers, a mounting cylinder, and a plunger assembly, as shown in Figs. 2, 5, and 6. The cylinder is 6 in. in length. The lower end is tapered on the inside to fit snugly over the base plate, and the upper half is gradually tapered from an inside diameter of 3 to $3\frac{1}{2}$ in. A 10-mesh screen, which can be removed through the top of the cylinder, rests loosely against a stop in the lower end at a point about 1 in. above the base plate when the cylinder is in position.

The transverse resistivity of a homogeneous material in board form is measured by cutting a disk-shaped specimen approximately $3\frac{1}{16}$ in. in diameter and inserting it in the tapered upper half of the cylinder until it fits tightly, as shown in Fig. 5. Coating the edge of the specimen with heavy grease may be necessary for some types of material in order to form an airtight seal with the wall of the cylinder. The cylinder is set onto the base plate with a grease seal, and air is drawn through the specimen. The resistivity, r, is determined from the relation:

$$r = \frac{PA}{QT}$$

where A and T are the area and thickness of the specimen, respectively.

In measuring the transverse resistivity of soft, compressible mats, it is possible for the thickness of the specimen after mounting in the cylinder to differ by an unknown amount from its original thickness, due to compression or distortion while being placed in the cylinder. This may be overcome by

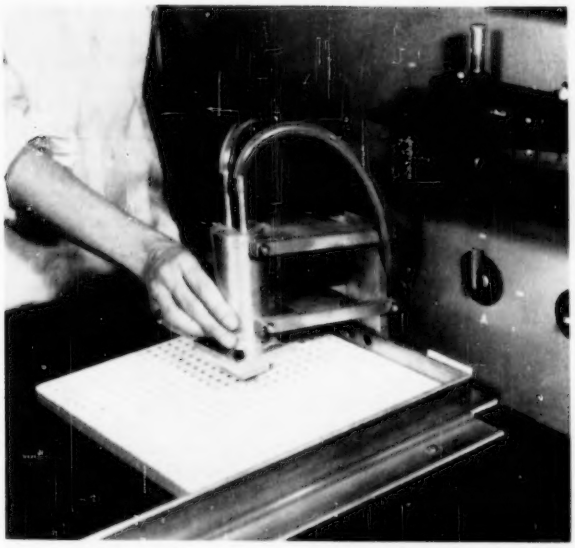

Fig. 3.—Test of Integrally Perforated Tiles.

wrapping a sleeve of heavy paper around the specimen and carefully inserting the sleeve in the cylinder until a snug fit is obtained. The resistance of such specimens is usually so low that no greasing or special precautions for edge sealing will be necessary.

The plunger assembly shown in Figs. 2 and 6 is used for setting the thickness of a loose or very soft material to a definite and accurately known value for transverse resistivity measurements, and also for determining the transverse resistivity of a compressible material as a function of thickness or density. The yoke of the plunger assembly can be quickly clamped onto the top of the cylinder, into which the removable

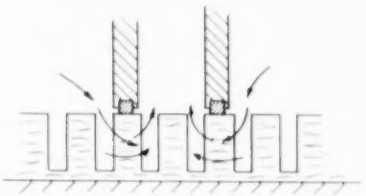

Fig. 4.—Path of Air Flow in Test of Integrally Perforated Materials.

lower screen has been placed. A similar 10-mesh screen is fixed to the bottom of the plunger, which can slide freely within the cylinder. The separation between the two screens is calibrated in sixteenths of an inch on the plunger rod and is read at the point where the rod passes through the top of the yoke. The plunger is fixed in position by the turn screw in the yoke.

The lateral resistivity of a homogeneous material in board form is measured by cutting a ring-shaped specimen from the board, as shown in Fig. 7. The outside diameter is approximately 3 in., to match that of the base plate, and the inside diameter is approximately 1¼ in., which is sufficient to clear the two holes in the base plate. The specimen is sealed to the base plate by a continuous coating of grease and the cover plate shown in Fig. 7 is likewise sealed to the top face of the specimen. When the air flow is set up, it is drawn radially through the specimen from the outer to the inner circumference, in directions parallel to the board surfaces, as shown in Fig. 8. The formula for determining the lateral resistivity of the specimen from the resistance measurement is:

$$r = \frac{2\pi TP}{Q \log_e (B/A)} = \frac{2.73TP}{Q \log_{10} (B/A)}$$

where:

T = thickness of specimen, face to face,
A = inside diameter, and
B = outside diameter.

The B mounting system is also adaptable to other types of tests involving special sample mountings that could be designed to fit either into the cylinder or onto the base plate; Beranek,[2] for example, describes a mounting for testing membranes, fabrics, etc. The B system is of course not restricted to tests on homogeneous materials. For example, a material might be composed

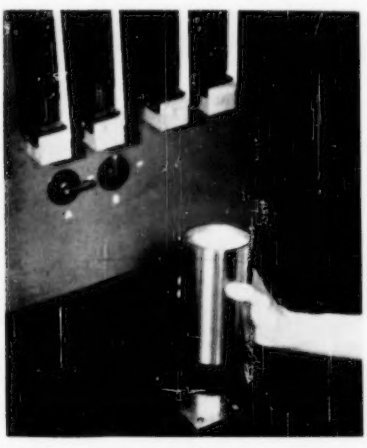

Fig. 5.—Transverse Resistivity Test of Homogeneous Board-Type Material.

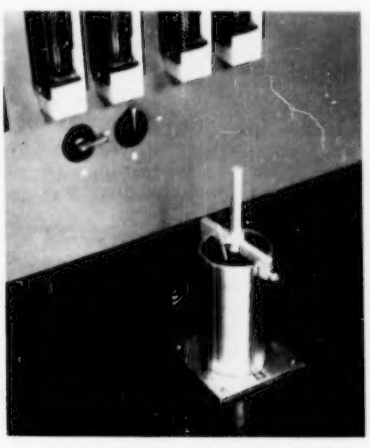

Fig. 6.—Transverse Resistivity Test of Compressible Material.

Fig. 7.—Lateral Resistivity Test of Homogeneous Board-Type Material.

of layers of differing resistivity, in which case a measurement of the resistance of the whole specimen rather than resistivity would be of more significance.

Procedure

When filling the water tank, the safety stopcock, *11* in Fig. 1, should be left open to avoid accidentally building up excessive pressure in the air line.

The value of air flow used in a particular test is more or less arbitrary, since the resistance is determined only by its ratio to the corresponding pressure reading. This is true, however, only in the velocity range of streamline air flow through the pores of the specimen where its resistance is independent of air velocity. If the rate of air flow through a given specimen is increased beyond a certain point, turbulent flow through its porous structure will commence, and the resistance will increase with increasing air velocity. Preliminary tests covering a wide range of air velocities should be run on each new type of material to determine the velocity range of streamline flow.

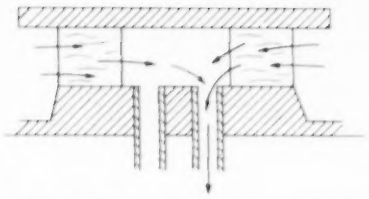

Fig. 8.—Path of Air Flow in Measurement of Lateral Resistivity of Ring-Shaped Specimen.

In tests on a series of samples in which the dimensions are constant and the test value from one specimen to another varies only with the air flow and pressure readings, it is convenient to use a fixed value of air flow chosen in such a way that the resistance or resistivity value will be a simple multiple or fraction of the pressure reading, so that the manometer will be a semi-direct-reading indicator of the desired test value. In this case, the air flow is set to the selected reading for each test. When using large air flows, this can be conveniently done by opening completely the needle valve on the rotameter being used and adjusting the air flow by means of the water drain valve, *10*. With smaller air flows it will be found that closer control of air flow as well as steadier rotameter readings can be obtained by adjustment of the rotameter needle valve. The procedure in this case is to close all of the rotameter needle valves, open the water drain valve completely, and allow water to drain until it is stopped or nearly stopped by the partial vacuum in the tank and air-flow line. Air flow is then started by opening the needle valve on the desired rotameter and adjusting to the required reading.

Discussion of Papers on Stress Relaxation of Vulcanized Rubber and Gasket Materials

EDITOR'S NOTE.—At the meeting of Committee D-11 on Rubber and Rubber-Like Materials held in Cincinnati during ASTM Committee Week January 31–February 4, 1955, the committee sponsored a Symposium on Relaxation of Gasket Materials. The two papers presented were published in the July 1955 BULLETIN: "Stress Relaxation of Vulcanized Rubber in Compression and Tension," by S. A. Eller, p. 78 (TP150); and "Stress Relaxation of Nonmetallic Gasket Materials," by D. R. Lem and J. M. Reynar, p. 81 (TP153). During the discussion which followed, F. C. Thorn commented on the papers presented and indicated that he would present additional data on a subsequent occasion. Following is an extension of Mr. Thorn's remarks as presented at the June meeting of Committee D-11.

At the D-11 Relaxation Symposium, the writer made a few observations, which are believed to be still valid. Briefly, these were as follows:

1. A commercial relaxation test must of necessity be a jig test, in the interests of both reduced cost of equipment, and the desirability of conducting tests at service temperatures.

2. Prior jigs, except for the Navy jig, have been deficient in the means available for indicating the exact point of initiation of recompression, which, under the procedure originally devised by Hopkins,[1] is taken to be the relaxed load. In the Navy jig this is accomplished in a sensitive manner, by noting the change in an electrical resistance meter when the insulated upper platen breaks contact with the shoulder of the locking plate.

3. The Navy jig, although quite satisfactory for tests run under predetermined strain, as in Navy bulkhead gasketing compressed to a fixed thickness, is not suitable for commercial flange gasketing, in which the predetermined factor is stress. In a jig employing the predetermined stress principle, the locking device cannot be positioned ahead of time by being bolted down solidly. It must be applied while the upper platen is under load, which means that it is subject to cocking.

4. When an attempt is made to determine relaxed load by breaking contact between the upper platen and a cocked locking collar, the electrical signal is not sharp but blurred, leading to nonreproducible relaxed load readings. Attempts to guide the locking collar in reference to the upper platen to insure a sharp electrical signal were unsuccessful.

5. A promise was made to attempt to simplify the jig by reducing the locking device to a simple thumb-screw, lying in the neutral axis and thereby free from cocking.

The simplification was made and is shown in Fig. 1. The device, which will be referred to as a "center-locked" jig, is quite simple and inexpensive. The present quotation is about $46 each.

Experiments were carried out on the 1.129 by $\frac{1}{2}$-in. cylindrical specimen or, alternately, eight separate 1.129 by $\frac{1}{16}$-in. disks of gasket material separated by 1.5 by $\frac{1}{16}$-in. steel separators. Other things being equal, the greater the thickness of material subject to compression, the more accurate the relaxed load reading.

Results obtained on $\frac{1}{16}$-in. drum-cured red rubber sheet, which conforms to ASTM Specification D 1330,[2] are

[1] Irving L. Hopkins, "Relaxation of Rubber-Like Materials," *Proceedings*, Am. Soc. Testing Mats., Vol. 43, p. 1202 (1943).

[2] Tentative Specification for Sheet Rubber Packing (D 1330 – 54 T), 1954 Supplement to Book of ASTM Standards, Part 6, p. 166.

[3] Tentative Specification for Non-metallic Gasket Materials for General Automotive and Aeronautical Purposes (D 1170 – 54 T), 1954 Supplement to Book of ASTM Standards, Part 6, p. 155.

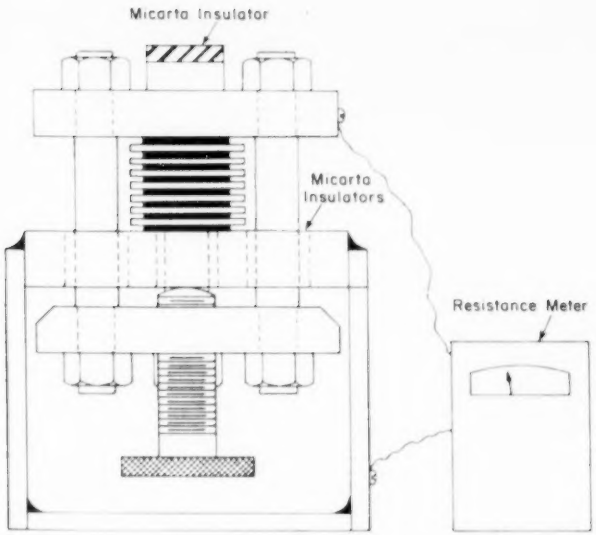

Fig. 1.—Center-Locked Jig.

TABLE I—RESULTS OF GASKET RELAXATION TESTS.

Material	Initial Load, psi	Aged 22 hr at:	Relaxed Load, psi	Relaxation, per cent
Red sheet	2000	Room temperature	1530	23.5
	2000	Room temperature	1440	28
	2000	Room temperature	1480	26
	2000	Room temperature	1570	21.5
	2000	158 F	230	88.5
	2000	158 F	180	91
	2000	158 F	280	86
	2000	212 F	0	100
Cork paper, glue-glycerine binder	1000	158 F	100	90
	1000	212 F	0	100
Compressed asbestos sheet	5000	212 F	600	88
Same, retightened	5000	212 F	2380	52

shown in Table I. A Baldwin Southwark machine was used to apply the load—a Farnam-Cole Relaxometer would have done equally well.

Results on the red sheet indicate both fair reproducibility and the profound effect of temperature, which is not revealed by any procedure involving relaxation at room temperature only. This method, which involves the "cold-to-cold" procedure, includes relaxation due to thermal contraction at the end of the test. This is a large factor. Independent tests with other equipment have shown relaxation of this sheet to be about 60 per cent instead of 100 per cent, if thermal contraction is excluded. Thermal contraction, is, however, present in commercial flanges. It is common experience that gaskets, especially rubber gaskets, leak more rapidly when cold than when hot. The effect would be more serious than it is if it were not for the fortunate circumstance that a gasket is usually relieved of pressure at the same time that it is relieved of temperature. This is not always the case, however, as for example when a steam joint in a line is closed by a down-stream valve.

Another discrepancy between the test and service is that in the laboratory there is no following effect due to bolt stretch which operates as a mitigating circumstance in commercial joints. For instance, the same sheet—tested 24 hr at 212 F in an ASA 400 Series flange, where about a 0.002-in. bolt stretch is available for follow-up—is found to have lost only about 80 per cent of an initial 2000-psi load on cooling, as shown by delicate bolt-length measurements. In a laboratory test, however, it is necessary to simplify. Since no two joints are alike in their available bolt stretch, it is necessary to work with a condition of no bolt stretch, that is, pure relaxation.

A third discrepancy is that in service gaskets are generally retightened at least once during the first 24 hr, which introduces secondary relaxation cycles of diminishing intensity. Again, in the interest of simplification and speed, we have omitted this step. Results are still of value for comparative purposes but should not be taken to indicate that this particular sheet is worthless for service at 212 F; this is far from the case.

Also shown in Table I are results on gasket types contained in ASTM Specification D 1170.[4]

In the case of compressed asbestos sheet, a departure from the original program to the extent of a single retightening seemed advisable because compressed asbestos gaskets are not recommended for hot service without such retightening.

Obviously the test needs perfecting in respect to platen finish, size and number of specimens, rate of initial tightening, aging procedures, etc. It does, however, offer the promise of an inexpensive and workable relaxation procedure for gaskets.

High-Speed Tension Testing Machine for Plastics*

By James Dorsey, Frederick J. McGarry, and Albert G. H. Dietz

This apparatus records stress-strain data during a tension test that consumes 5 to 15 milliseconds from start of loading to fracture—permanent records of strain information made by oscilloscope cameras.

THE MECHANICAL properties of polymeric materials are particularly time-sensitive, as manifested by creep under constant stress and relaxation of stress under fixed deformation. Another consequence of this time-sensitivity is the variation in stress-strain behavior at various rates of test. For example, in a series of tension tests in which the strain rate is increased from test to test, the following effects are usually noted:[1]

1. The initial slope of the stress-strain curve, the apparent modulus of elasticity, increases.
2. The strain at fracture decreases.
3. The stress at fracture increases.
4. The energy to fracture, defined by the area under the stress-strain curve, rarely shows such consistent variations, with increasing strain rate, as those mentioned above.

Mechanical testing equipment[2,3] has been developed for polymeric materials which largely eliminates the human factor in providing positive continuous control of machine speed, automatic recording, and automatic cycling of load or deformation, but this equipment is largely confined to the 0.001 to 10 in. per min testing range. Experience in this time range demonstrates the difficulty of extrapolating mechanical properties of polymers from one time range to another.[4] This is especially true of strength, which involves the little-understood mechanism of fracture. The only safe approach, therefore, is to test materials at the desired rates.

Plastics are attractive for many applications involving large accelerations because the low specific gravity of most plastics reduces the total energy required to achieve such accelerations. It is necessary, however, to know something of the mechanical properties of the plastic under high accelerations. Consequently, a high-speed tension testing device has been developed which allows a determination of the tensile stress-strain behavior in a test completed in a few milliseconds from no load to fracture. The device could not be practicably designed for constant rate of load, strain, or crosshead motion, but under certain test conditions, reasonable approximations to one of these three may be approached.[5] On the other hand, the total time interval for the test can be varied over fairly wide limits.

Mechanical Design

The essence of the rapid testing device is presented in Fig. 1 and represents a modification of an apparatus conceived by Shepler.[6] An annular shaped piston, *6* fabricated from duralumin 24-ST-4 seats and travels in a steel cylinder, *3*. One end of the specimen, *7* is clamped to the anvil portion of the piston while the other end is held in a stationary set of jaws, *5*, suspended from a tubular steel weighbar, *2*. When high-pressure nitrogen gas is suddenly admitted against the face of the piston through the inlet port, *8*, by means of a fast-acting, manually operated valve, the piston is forced out of the cylinder,

JAMES DORSEY, a graduate of Massachusetts Institute of Technology, Cambridge, Mass., is a research staff member of the MIT Plastics Research Laboratory in the field of high-speed testing and associated instrumentation.

FREDERICK J. McGARRY, Assistant Professor of Materials, MIT, is engaged primarily in the study of the mechanical properties of plastics and the development of various test methods to determine such properties.

ALBERT G. H. DIETZ, Professor of Building Engineering and Construction, has been on the MIT staff since 1934, with leaves of absence to Office of Scientific Research and Development, Office of Field Service during World War II.

NOTE—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

* Presented at the Fifty-Eighth Annual Meeting of the Society, June 26-July 1, 1955.

[1] A. G. H. Dietz, W. J. Gailus, and S. Yurenka, "Effect of Speed of Test Upon Strength Properties of Plastics," *Proceedings*, Am. Soc. Testing Mats., Vol. 48, p. 1160 (1948).

[2] G. S. Burr, W. J. Gailus, J. O. Silvey, S. Yurenka, A. G. H. Dietz, "Universal Plastics Testing Machine," ASTM BULLETIN No. 149, December 1947, p. 51.

[3] F. J. McGarry and A. G. H. Dietz, "An Extensometer for Polymeric Materials," *Review of Scientific Instruments*, Vol. 25, No. 8, August 1954, pp. 740-745.

[4] R. N. Haward, "The Strength of Plastics and Glass," Interscience Publishers Inc., New York, N. Y., 245 pp. (1949). See Chapter 2, "The Static Strength of Plastic Materials."

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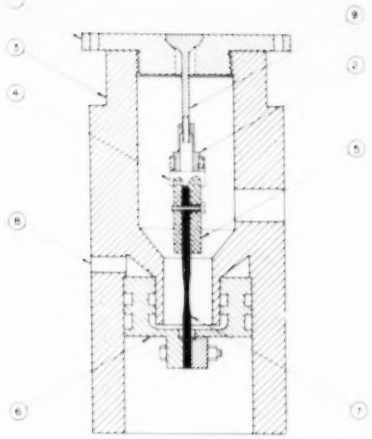

Fig. 1. Section View of High-Speed Testing Chamber.

(1) Mounting plate. (2) Load cell. (3) Cylinder. (4) Clamp mount. (5) Stationary clamps. (6) Piston. (7) Specimen. (8) Gas inlet port. (9) Connecting link.

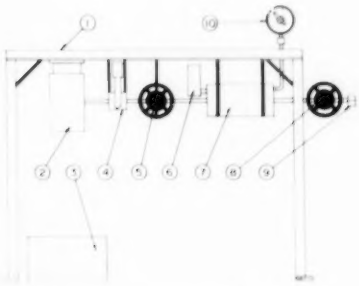

Fig. 2. Schematic of High-Speed Testing Apparatus.

(1) Tester stand. (2) Cylinder and piston (Detail in Fig. 1). (3) Damping box. (4) Fast acting valve and trigger. (5) Hand valve. (6) Safety valve. (7) Firing reservoir. (8) Handvalve. (9) Gas inlet. (10) Pressure gage.

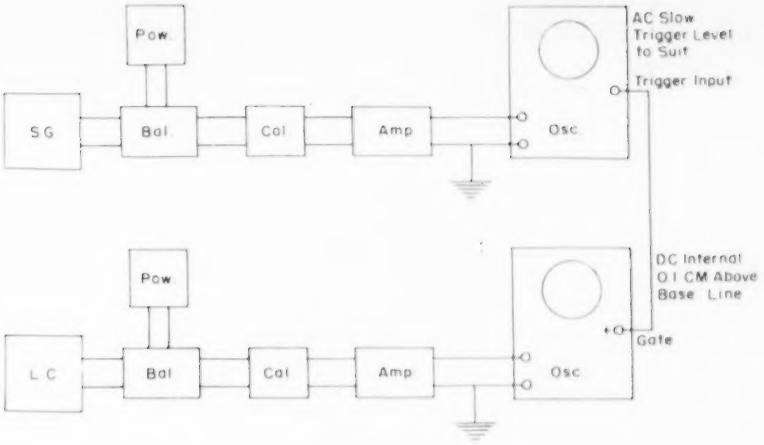

Fig. 3. Testing Apparatus Instrumentation—Block Diagram.

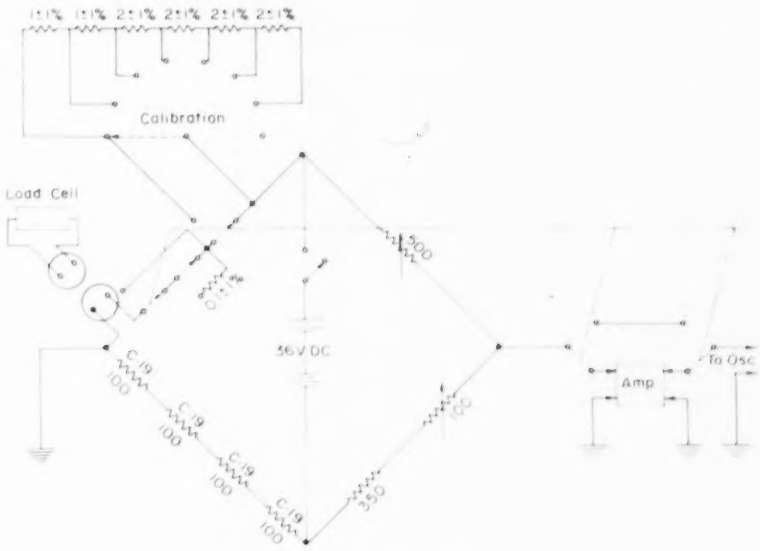

Fig. 4. Load Cell Circuit.

deforming and breaking the specimen in tension. The area of the piston exposed to the actuating gas pressure is approximately 10 sq in. while the system has been designed for a maximum pressure of 6000 psi; hence the theoretically available force to impose upon the specimen is 60,000 lb. In practice, loads have not exceeded 500 lb. Figure 2 is a schematic view of the complete apparatus exclusive of instrumentation.

The mechanical characteristics of the specimen material strongly influence the displacement-time performance of the piston. As a consequence, it is usually necessary when examining a new material, to carry out a few tests with various gas pressures until a satisfactory load-time or strain-time performance is attained. Usually some five specimens would be expended, hence the difficulty is not formidable.

The specimen usually used, as shown in Fig. 1, is approximately 6 in. long. At each end a rectangular cross-section $\frac{1}{4}$ in. by $\frac{1}{2}$ in. by 2 in. long is gradually transformed to a $1\frac{1}{4}$-in. long central gage section 0.250 in. square. Numerous tests on such specimens have been performed. In addition, to study speed effects with tacky adhesives, the apparatus was successfully used with polyisobutylene bonds approximately 0.10 in. thick between steel surfaces of the button type common to adhesives testing.

Instrumentation

Instrumentation was designed to present data as direct-reading graphs of load *versus* time and strain *versus* time. Although many existing systems will record these data in the 0.001 to 10 in. per min region, transients of the duration and wave form encountered in testing at high speeds present additional problems, two of which are electrical noise and actuation of the time-recording systems. Figure 3 is a block diagram of the instrumentation in its final form and Figs. 4 and 5 present the load and strain channels, respectively. Origi-

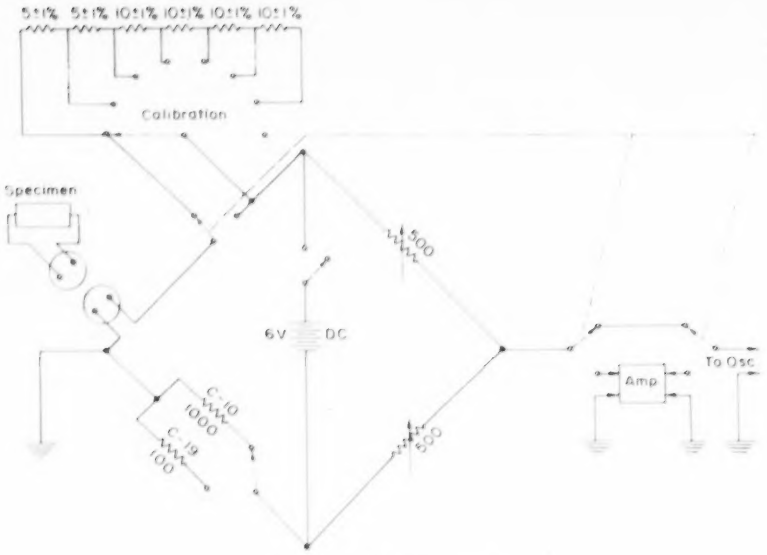

Fig. 5. Strain Gage Circuit.

nally there were no commercial oscilloscopes available with both high gain dc and precise internal triggering; thus the use of the best equipment available produced triggering, interference, calibration, and synchronization difficulties. Recently, however, a much improved oscilloscope[6] which virtually eliminated all of these problems was produced. The apparatus is now equipped with two of these, providing calibrated, direct-reading data and internal triggering. Data are recorded on two Polaroid oscilloscope cameras.[7]

Load Cell Channel

For dynamic testing, a load cell must possess, in addition to the necessary static characteristics, a natural frequency high enough to prevent vibrations of the load-measuring unit from indicating false loads.[8,9,10] With these criteria in mind, the apparatus was equipped with a 500-lb capacity steel load cell having a natural frequency of 9000 cps. A potentiometer-type connection[11] was used for the load cell strain gages[12] because of its increased sensitivity over the equivalent bridge circuit. Calibration is accomplished by means of precision resistors inserted in the load cell branch of the bridge. Careful selection of a decade amplifier[13] and the use of dry-cell bridge drivers and doubly balanced bridge arms eliminated most of the electrical noise which is a usual cause of difficulty at such low levels of signal potential. As an additional feature, alignment of the instrumentation may be checked prior to each test by inserting a 0.1 ohm resistor in the load cell branch of the bridge causing the sweep to be triggered.

Strain Gage Channel

Basically the strain gage channel, shown in Fig. 5, is the same as the load channel. A choice of two internal dummy resistances is offered such that any 100 ohm or 1000 ohm gage may be used without resorting to an external dummy. Noise was never found to be bothersome in the strain gage circuitry because of the high signal level.

Two or more of the above strain units are used simultaneously to produce data from various areas and directions on the specimen. In this manner, the equipment was tested for alignment of the grips. The possible presence of wave effects in specimens during tests was also investigated by using two strain gages and channels. The strain signal may also be substituted for the calibrated sweep, yielding a load *versus* strain record. This procedure is not generally employed because none of the testing rates (crosshead, strain, or load) is completely constant.

Results

Figure 6 presents data from a single test on commercial methyl-methacrylate. Information is received from the oscilloscope cameras in the form shown except that load is plotted rather than stress. In Fig. 7 stress and strain from the above tests are plotted along with data from a low-rate test supplied by the Plastics Materials Manufacturers'

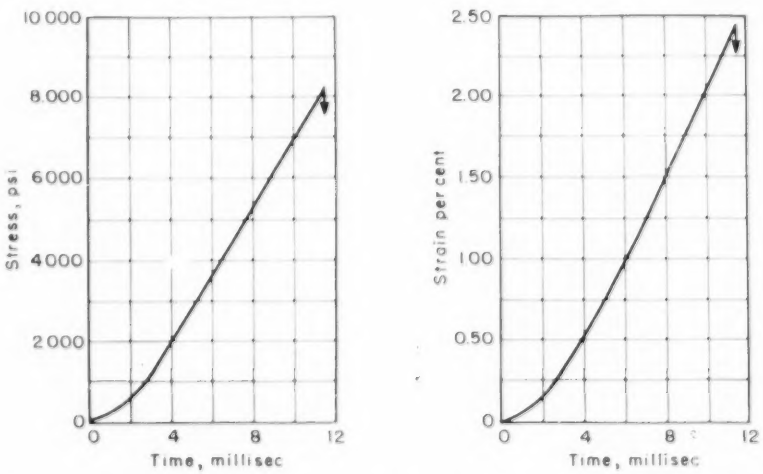

Fig. 6. Stress *versus* Time Strain *versus* Time. For Acrylic at 150 in. per min Crosshead Rate.

[6] "Cathode-Ray Oscilloscopes, Auxiliary Instruments and Accessories," Tektronix Inc., Portland Ore. (March 1954).

[7] "A Catalogue of Equipment for Oscillography," 9th Ed., Allen B. DuMont Laboratories, Inc., Clifton, N. J. (May 1953).

[8] J. P. Den Hartog, "Mechanical Vibrations," 3rd Ed., McGraw-Hill Book Co., New York, N. Y. (1947).

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[12] "SR-4 Strain Gages, Instruments and Accessories," Baldwin-Lima-Hamilton Corp., Philadelphia, Pa. (July 1953).

[13] Hermon Hosmer Scott, Inc., Cambridge, Mass.

Assn.[14,15] For this pair of tests, the 7.8 per cent strain experienced by the specimen tested at a low rate represents over three times the 2.5 per cent strain of a similar specimen at high rates. In addition, the rupture stress for the low-rate specimen is only about 90 per cent as great. The most pronounced and perhaps most important result obtained from such data is the difference of energy to fracture (area under the curve) for different testing rates. For the set of tests plotted in Fig. 7 the energy to fracture for the low-rate test is 471 in-lb per cu in., and for the high-rate test 105 in-lb per cu in.; a ratio of 4.5 to 1.

Figure 8 plots data at the same two rates for a lower modulus material. In this case the strains of 15.4 per cent and 0.7 per cent represent a ratio of 22 to 1, while the low-rate stress figure of 920 psi is slightly over 80 per cent of the 1120 psi stress figure obtained from the high-rate test. The rate effect on the energy to fracture is often more pronounced the lower the modulus of the high polymer. Thus, for the tests of Fig. 8, the low- and high-rate tests give energy value of 130.0 and 3.5 in-lb per cu in., respectively, a ratio of 37 to 1.

Although the results discussed here are for representative single tests of only two materials, the information derived is indicative of results obtained with high polymer materials at varying rates. Future work with the testing apparatus is expected to produce data leading to a better understanding of high polymer behavior in the range between static and dynamic testing.

Acknowledgment:

The high speed testing device was one of the developments produced under Contract DA-19-020-ORD-6, Bureau of Ordnance, supervised by Picatinny Arsenal, Dover, N.J., where the apparatus is now located. L. Gilman and H. Sigler of the Plastics Section, Picatinny Arsenal, were of continual assistance throughout the duration of this contract, offering much valuable advice and suggestions. Numerous members of the MIT Plastics Research Laboratory staff also contributed to the progress of the work. These include Jan G. Krizik, Harold E. Lerner, and Milton S. Cohen.

[14] "Technical Data on Plastics," Plastics Materials Manufacturers' Assn., Inc., Washington, D.C. (May 1948).

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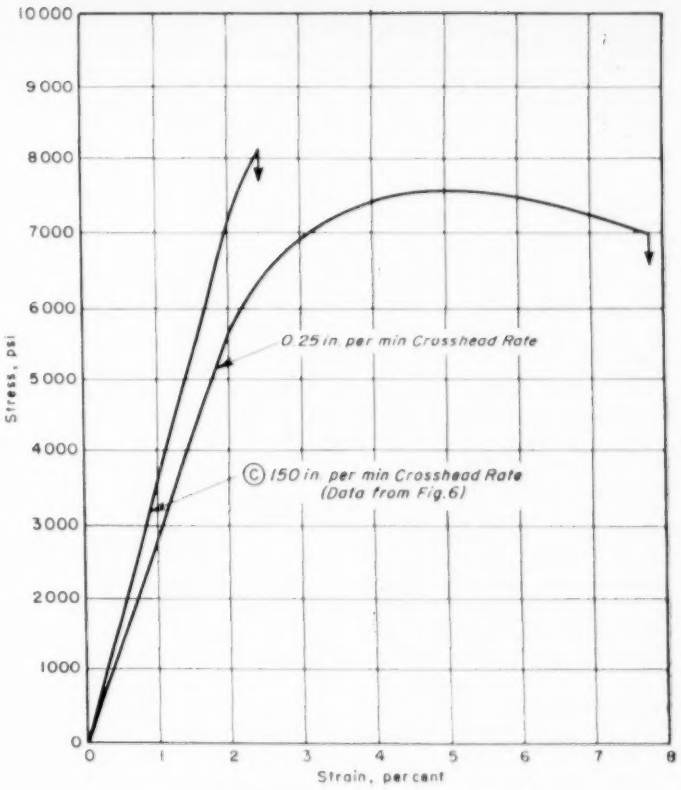

Fig. 7. Stress *versus* Strain for Acrylic at Two Rates.

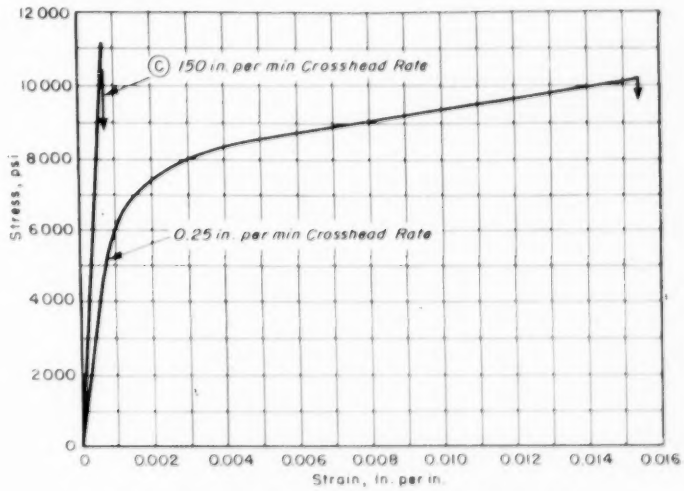

Fig. 8. Stress *versus* Strain for Low Modulus Plastic.

A Bend-Test Method of Determining the Stress Required to Cause Creep in Tension[1]

By J. B. Wachtman, Jr., and L. H. Maxwell

Some materials require a rather well-defined stress to cause creep in tension. A method is described which permits the use of bending tests to determine this stress under conditions which make tension testing difficult.

In this paper, the stress required to cause creep is considered to be the stress that causes a specified amount of creep within a limited period of time. This will be referred to as "creep yield stress."

In studying the creep properties of sapphire at 1000 C, the creep yield stress, defined as the stress necessary to cause more than 0.01 per cent strain in 100 hr, was measured **(1, 2)**.[2] Sapphire specimens were loaded in increments at 100-hr intervals and observed for creep. It was found that either no creep or creep much greater than 0.01 per cent took place for a given load. Evidently, the creep yield stress is a definite property of sapphire at 1000 C and may be for other materials.

It is not always possible to perform tension tests as easily as bend tests. Some materials are available only in small pieces, and high-temperature tension tests may not be possible. Bend testing of small pieces is comparatively simple experimentally. Nadai **(3)** has discussed the plastic bending of a bar and has shown how the stress-strain curve may be obtained for time-independent deformation. This paper is intended to apply to a special problem in time-dependent deformation.

Elastic Bending

The formulas for the tensile stress in the outer fiber of an elastically bent sample are well known **(4)**:

$$\sigma_{er} = \frac{4M}{\pi r^3} \quad \text{for a circular rod} \quad (1)$$

$$\sigma_{er} = \frac{6M}{bh^2} \quad \text{for a rectangular bar} \quad (2)$$

where M is the bending moment and b, h, and r represent the dimensions as shown in Fig. 1. If the creep yield stress is determined in bending by using these formulas and loading in increments as in tension testing, the computed creep yield stress may be higher than the true value. This will be seen from the discussion of plastic bending.

Plastic Bending

It is assumed that the mechanical properties are the same in compression as in tension. When the creep yield stress is exceeded in the outer fiber, the specimen will bend plastically until the stress in the outer fiber has fallen to this value. The sample will then be divided into regions, as is shown in Fig. 2 for the rod. The tensile (or compressive) stress is:

$$\sigma = \frac{y}{j}\sigma_0 \quad \text{when } j \geq y \geq 0 \quad (3)$$

$$\sigma = \sigma_0 \quad \text{when } r \geq y \geq j \quad (4)$$

where j is the value of y at the boundary of the elastic region and σ_0 is the creep yield stress. The elastic strain in the outer fiber, ϵ_r, is the same as the elastic strain at $y = j$. This strain can be expressed in terms of the radius of curvature, R, as shown in Fig. 3

$$\epsilon_r = \frac{j}{R} \quad (5)$$

The total strain in the outer fiber is the elastic strain, ϵ_r, plus the plastic strain, ϵ_p.

$$\epsilon_r + \epsilon_p = \frac{r}{R} \quad (6)$$

Let:

$$Z = \frac{\epsilon_r}{\epsilon_r + \epsilon_p} \quad (7)$$

For the circular rod, from Eqs. 5 and 6:

$$Z_r = \frac{j}{r} \quad (8)$$

Similarly, for the rectangular bar:

$$Z_b = \frac{2j}{h} \quad (9)$$

The following integration is for the rod. The stress σ_0 is the outer-fiber stress which we call σ_{pr} for the rod. The bending moment, M, must be:

$$M = 2\int_0^r \sigma y(2x)\,dy$$
$$= 2\int_0^j \sigma_{pr}\frac{y^2}{j}\left(2\sqrt{r^2 - y^2}\right)dy$$
$$+ 2\int_j^r \sigma_{pr}\, y\left(2\sqrt{r^2 - y^2}\right)dy \quad (10)$$

Performing the integrations, using Eqs. 3, 4, and 8, and rearranging:

$$\sigma_{pr} = \frac{\sigma_{er}}{k_r} \quad (11)$$

where:

$$k_r = \frac{16}{\pi}\left[\frac{1}{12}(1 - Z_r^2)^{3/2} + \frac{1}{8}(1 - Z_r^2)^{1/2} + \frac{\sin^{-1} Z_r}{8 Z_r}\right] \quad (12)$$

For a rectangular bar, the result is:

$$\sigma_{pb} = \frac{\sigma_{eb}}{k_b} \quad (13)$$

where:

$$k_b = \frac{3}{2}\left(1 - \frac{Z_b^2}{3}\right) \quad (14)$$

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[1] This work was performed on a project sponsored by the Aeronautical Research Laboratory, Air Research and Development Command, Wright Air Development Center, United States Air Force, Wright-Patterson Air Force Base, Ohio.

[2] The boldface numbers in parentheses refer to the list of references appended to this paper.

Figure 4 shows the dependence of k_r and k_b on the ratio of plastic to elastic strain in the outer fiber.

The possibility of obtaining an incorrect value of creep yield stress by using Eqs. 1 or 2 for elastic materials is evident from Fig. 2. When a bending moment causing an outer fiber stress just exceeding the creep yield stress is applied, large creep will not occur as it would in a tension test. The bending sample will creep until the stress has redistributed and creep will then cease. For example, if a bending moment sufficient to give σ_{y_i} equal to 1.1 times the creep yield stress is applied, a plastic strain of only 0.1 times the elastic strain will occur. Thus, unless the strain-measuring apparatus is very sensitive, the onset of creep may not be detected until considerable stress redistribution has taken place and the application of the elastic bending formula may result in considerable error.

Method of Determining Creep Yield Stress

The method consists essentially of determining the stress necessary to cause continuing creep ($k_r = 1.70$ or $k_b = 1.50$) instead of determining the stress required for the onset of creep ($k_r = k_b = 1.0$). It is suggested for use only when (*a*) tension tests are not possible, and (*b*) sample size and test conditions (temperature, atmosphere, etc.) make precise strain measurement difficult in bend testing. It is intended for materials having a well-defined creep yield stress not changed appreciably by previous continued loading at a lower stress. It is, of course, necessary to choose some finite amount of strain to indicate that the condition of continuing creep has been closely approached. The rapid convergence of k_r and k_b make this possible. Thus, if plastic strain of twice the elastic strain is chosen as the indication that the stage of continuing creep in bending has been reached, the limiting values of $k_r = 1.70$ or $k_b = 1.50$ may be used with an error of only 6 per cent. The error may be further reduced by choosing three times the elastic strain as indication that the condition of continuing creep in bending has been closely approached.

Example

The authors have determined the creep yield stress of round sapphire rods 0.100 in. in diameter at 1000 C in tension and in bending. The creep yield stress of sapphire must be expressed in resolved shear stress (**1, 2**) which is proportional to the tensile stress with the multiplying factor dependent on the crystallographic orientation of the sample. This does not affect the test method.

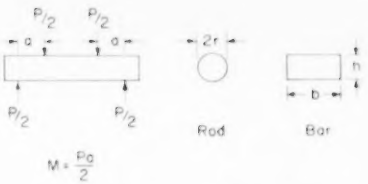

Fig. 1. Dimensions of Specimens.

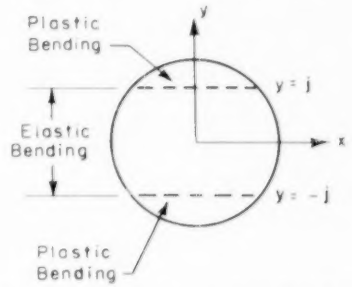

Fig. 2. Cross-section of a Bent Rod Perpendicular to the Rod Axis.

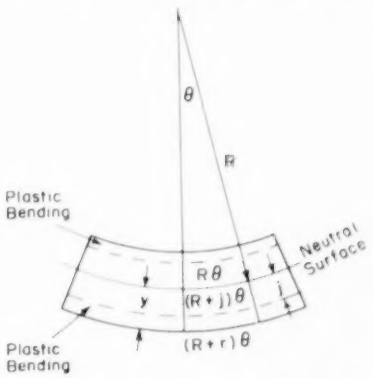

Fig. 3. Cross-section of a Bent Rod in the Plane of Bending.

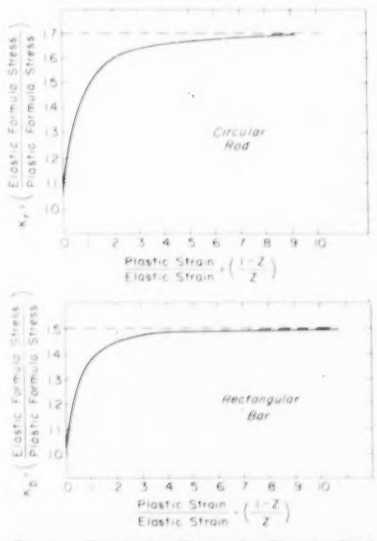

Fig. 4. Correction Factor for Circular Rod and Rectangular Rod in Plastic Bending.

A bending test made on a rod with resolved shear stress multiplying factor equal to 2.46 is typical. The creep yield stress was thought to be about 400 kg per sq cm resolved shear stress, so the first load used to test for continuing creep corresponding to 350 kg per sq cm. The tensile stress in the outer fiber was taken as 350 kg per sq cm × 2.46 × 1.70, and the elastic formula (Eq. 1) was used to calculate the necessary load. When the 100-hr period was over, the resolved shear stress was increased to 400 kg per sq cm. The history of the sample is as follows:

Resolved Shear Stress, kg per sq cm	Immediate Deflection, in.	Creep Deflection, in.	Time, hr
350	20×10^{-4}	4×10^{-4}	101.9
400	2	5	107.2
450	2	42	65.0

The immediate deflection is the amount of bending occurring within 10 sec after loading, and the creep deflection is the amount of deflection subsequently taking place under constant load. The first immediate deflection, 20×10^{-4} in., probably contains some settling of the apparatus. Accordingly, the immediate deflections under subsequent loads were used to compute the total elastic deflection; that is, the total elastic deflection was taken to be 18×10^{-4} in. ($9 \times 2 \times 10^{-4}$ in.) at 450 kg per sq cm. After 65 hr, a total plastic deflection of 51×10^{-4} in. had occurred, which is more than twice the total elastic deflection. The creep yield stress is thus known to be more than 400 kg per sq cm and less than 450 kg per sq cm and is taken to be 425 kg per sq cm.

The creep yield stress determined in tension compares well with the value obtained in bending:

tension 380 kg per sq cm (average of 8 samples) 150 kg per sq cm standard deviation)

bending 410 kg per sq cm. (average of 3 samples).

Acknowledgment:

The authors thank S. M. Lang and S. Levy for discussion.

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Tension Testing Apparatus for the Temperature Range of −320 F to −452 F

By E. T. Wessel

A relatively small, simple system economical to operate and capable of testing at loads to 20,000 lb maximum.

LOW-TEMPERATURE research is making important contributions to the understanding of the fundamentals governing the flow and fracture properties of metals and also in providing practical engineering data. The knowledge obtained at these low temperatures provides clues to the behavior of metals at normal operating temperatures. One aspect currently receiving considerable attention is the transition from ductile to brittle behavior. The objectives of such studies are concerned with the basic reasons for the transition, how microstructure and composition affect the temperature of transition, and the procurement of data which the designer may use to predict the behavior of the material in service. Other investigations may be directed towards studies of the basic mechanisms of deformation or the selection of materials for actual use at low temperatures. This paper is intended to describe new low-temperature tension testing equipment which will greatly facilitate such work.

The tension test at low temperatures proves to be a good tool to study these various factors in a quantitative way. In order to understand the behavior of materials it is necessary to ascertain flow and fracture stress, strain, and rate of work hardening at different strain rates. These properties can be measured in a controlled strain rate tension test, whereas a Charpy or Izod impact test, for example, is only capable of showing relative transition temperatures and energy absorptions.

Many investigators are using low-temperature tension testing as a tool but are hampered in their work by serious limitations in test apparatus and facilities. Usually the temperature range is fairly limited and in many cases is confined to a single temperature, that of the boiling point of the liquefied gas being used as the refrigerant, that is, liquid nitrogen, hydrogen, or helium. In cases when temperature can be varied, there are serious problems of temperature measurement and control. In order to conserve refrigerant, many of the systems are small and utilize glass Dewars for insulation, thereby confining operations to light loads and small specimens. Accurate measurements of strain become increasingly difficult to make at the lower temperatures since conventional extensometers and strain gages become unreliable or inoperative at these temperatures. Other systems in use are extremely complex, bulky, and expensive to build or operate. Eldin (1)[1] has reported a method of tension testing down to about −438 F in which the whole tension testing machine is lowered directly into a helium cryostat.

Description of Apparatus and Procedure

Apparatus has been developed which permits convenient and accurate tension testing at loads up to 20,000 lb at any temperature in the range from room temperature to −452 F. Two similar systems employing different refrigerants are used to produce and maintain test temperatures within this range. One established system (2,3) which is being used quite extensively in the range from room temperature to −320 F utilizes liquid nitrogen as the refrigerant. A second system, employing liquid helium as the refrigerant, has recently been developed to extend the range from −320 to −452 F.

It appeared reasonable to apply the same principles that were successful for the nitrogen system to similar apparatus utilizing liquid helium (boiling point −452 F [4.2 K]) as the refrigerant. The various problems become much more involved in the use of liquid helium, primarily because of its relatively low heat of vaporization (approximately 0.62 cal per mil[4]) and the relatively high cost of producing it. However, recent developments at the Westinghouse Research Laboratories (4,5,6) concerning the production, storage, and transfer of liquid helium greatly facilitated the work of developing suitable low-temperature testing facilities. The main problems were the design of an efficient test chamber, and the interrelated aspects of refrigerant flow regulation and temperature measurement and control.

The helium system, shown schematically in Fig. 1, is composed of three functional groups: the refrigerant storage and supply apparatus, the test chamber, and the flow regulating, temperature measurement and control mechanisms. The principles of operation are relatively simple. The chamber is precooled to −320 F using liquid nitrogen. Then the refrigerant, liquid helium, is moved from the storage Dewar to the precooled test chamber by imposing a slight over-pressure (2 to 5 oz gage) on the surface of the liquid by means of bottled pure helium gas. Once in the test chamber, the refrigerant extracts heat from the internal components of the chamber by two mechanisms—the acquisition of the necessary heat of vaporization by the liquid and, especially, the change in heat content of the gas as it rises to its exhaust temperature. Temperature control is achieved by suitable automatic regulation of the flow of refrigerant into the test chamber.

Storage and Transfer of Refrigerant

The helium production, storage, and transfer equipment is of the conventional cryogenic type and is described in detail in the literature (4,5,6). The liquid helium in storage is separated from atmospheric temperature by a vacuum cell, a liquid nitrogen bath, and a second vacuum cell. Transfer lines for the movement of liquefied gases from one container to another have been described by several authors (5,7,8,9,10). These transfer lines con-

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[1] The boldface numbers in parentheses refer to the list of references appended to this paper.

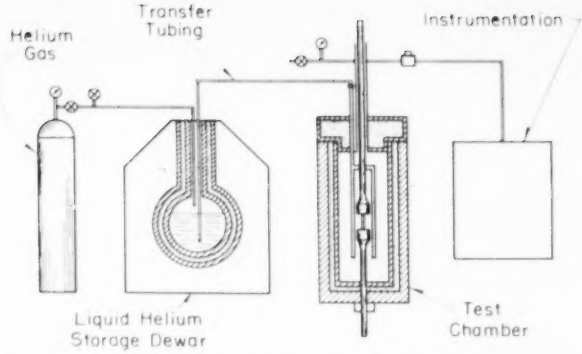

Fig. 1. Apparatus for Maintaining Test Temperatures in the Range −320 F to −452 F.

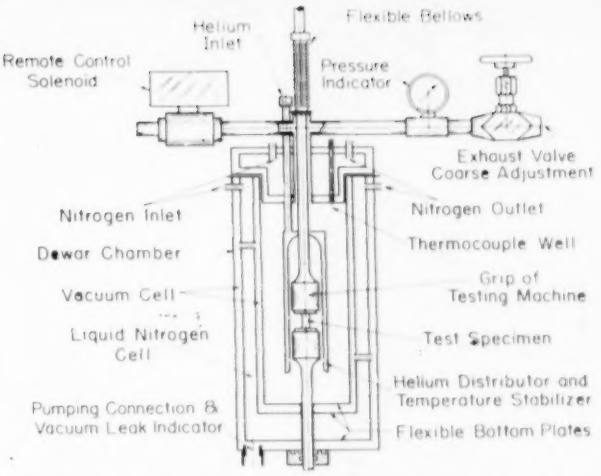

Fig. 2. Low-Temperature Test Chamber—Liquid Helium Refrigerant.

sist of a double-walled metal tube, the helium flow being in the inner passage while the outer cell is a vacuum jacket. The particular apparatus used in this work incorporated the desirable features of a liquid level gage (5) to indicate the remaining liquid content of the storage container and a convenient vacuum seal-off and safety valve (5). An efficiency of about 85 per cent is obtained with this equipment during the transfer of several liters of liquid helium.

Test Chamber

A problem of major concern is the design of a suitable test chamber. Since the available quantities of refrigerant are limited and the cost of producing liquid helium is a significant factor, considerable attention is given to the minimization of heat leaks and the initial heat content of the equipment to be cooled. This problem is further complicated since the demands of the intended test program made it desirable to design apparatus capable of bearing loads up to 20,000 lb.

The design features of the test chamber are illustrated in Fig. 2. A photograph of the opened chamber mounted in the tension testing machine is shown in Fig. 3. The chamber is approximately 5 in. in diameter by 15 in. long, in order to provide ready access to the test specimen, it is necessary to use two piece construction with test grips entering through the top and bottom parts of the chamber. As shown in Fig. 3, the lower section of the chamber has been slid down along the bottom grip while the integral lid assembly has been moved upward along the top grip. The "O" ring seals are provided at the entry points of both grips to maintain a gas-tight system. An "O" ring seal is also provided at the interface where the two sections of the chamber come together, and springs that are attached to the top and bottom sections are used to compress this "O" ring and to maintain intimate contact during testing. The maintenance of a gas-tight seal between the lid and bottom interfaces is an absolute necessity for good temperature control. If a small leak develops in this seal, the passage of the cold vapor tends rapidly to magnify the size of the leak and the back pressure in the chamber is lost, causing the temperature control principles to cease functioning properly. Some difficulty was encountered in early tests in this respect, but it was overcome by the use of a ring of modeling clay to supplement the conventional "O" ring seal. An improved design should provide for better clamping of the two components with more positive pressure on the "O" ring and the use of a better sealing material.

The arrangement of the test machine and grips is such that the top grip remains stationary while the lower grip is extended during the actual test. The whole test chamber moves along with the lower grip during the test. The purpose of the flexible stainless steel bellows shown on the lid in Fig. 2 is to reduce friction or drag and to absorb the movement of the test chamber during the test. It also serves to absorb much of the shock imparted to the chamber when the specimen ruptures.

As may best be seen in Fig. 2, the thermal insulation principles used so successfully for liquid helium storage Dewars have been applied to the test chamber. The inner and outer vacuum cells are joined by small connecting tubes that serve a dual purpose in that they make it possible to evacuate the inner cell by pumping through one seal in the outer cell and also provide constructional rigidity. The cell walls are made of AISI Type 310 stainless steel tubing of 0.010 in. wall thickness. The wall thickness must be kept small to help minimize heat leaks and initial heat content. As a precaution against collapse during evacuation and to add to the structural rigidity, narrow supporting rings are brazed to the tube walls at periodic intervals. Type 310 stainless steel is used because of its desirable properties of low thermal conductivity, low specific heat, retention of ductility and metallurgical stability at low temperatures, and good corrosion resistance. The top and bottom grip entry wells are likewise made of stainless steel tubing with an especially reduced cross-section between the nitrogen bath and the inner cell of the test chamber to minimize the heat flow. A close sliding fit is provided between the bottom grip and the bottom well so there will be opportunity for efficient heat transfer between the grip and the nitrogen bath. The entry well for the top grip is made considerably larger than the grip diameter in order to provide a passageway for the helium gas that is being exhausted from the test chamber. The cold exhaust gas withdraws most of the heat being conducted into the chamber through the top grip as it passes out along it. An exhaust manifold is connected to the top grip well for the purpose of regulating the refrigerant flow. Its function will be described in more detail in a later section of the paper. The flexible bottom plates indicated in Fig. 2 are made of thin stainless steel sheet and act much in the manner of a diaphragm to absorb the dimensional changes taking place in the chamber during heating and cooling. A thin stainless steel tube is also provided in the lid for a thermocouple well, the head of the thermocouple being affixed directly to the test sample.

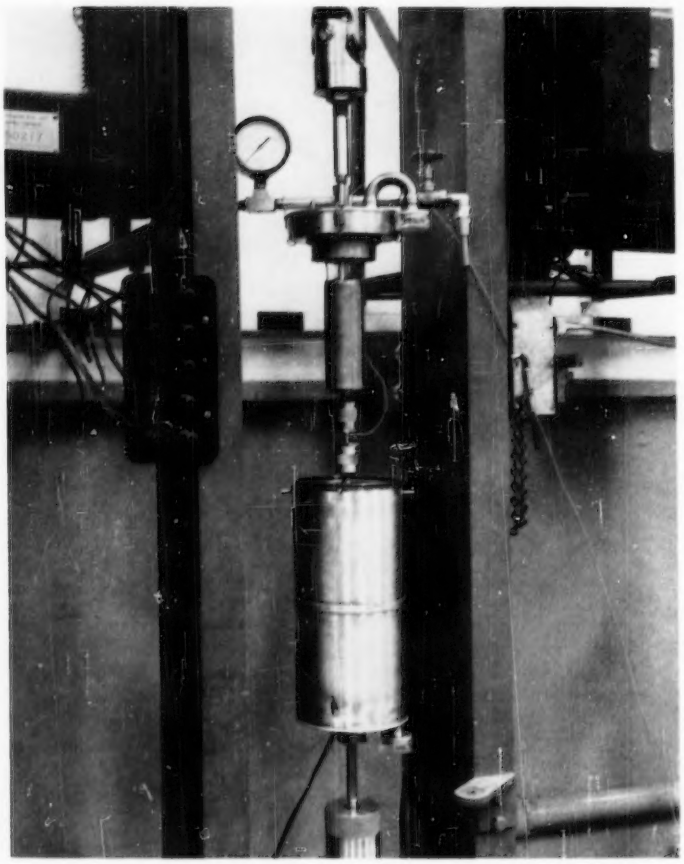

Fig. 3.—Chamber for Tension Tests in the Temperature Range of −320 F to −452 F.

The refrigerant inlet tube and dispenser are integral parts of the lid assembly. The helium transfer tube is inserted through the thin-walled inlet passageway to the point where the dispenser connects with the inlet. The dispenser is a double-walled cylinder with sealed ends and numerous small holes in the inner wall through which the helium mist is ejected onto the heads of the test grips and the test specimen. In addition to dispensing the refrigerant, this arrangement provides a confining and stabilizing effect upon the vapor immediately surrounding the test sample and the heads of the grips. For this purpose, the distributor is constructed of copper because of its high thermal conductivity which provides more uniform temperature distribution. A wall thickness of 0.020 in. is used to attain a balance between temperature stabilization and a high heat content.

Since the two test machine grips represent the major sources of heat leaks and the initial heat content and are the load bearing members, considerable attention was given to the choice of a suitable material. An ideal material would have all the following properties.

1. A high room-temperature yield strength so that the grip diameter could be kept small, thereby presenting as little area as possible through which heat could flow and to minimize the physical mass, thereby the initial heat content of the portions to be cooled. (Although the yield strength of most metals increases with decreasing temperature, the design must be based on the strength of the portion of the grip which is outside the chamber and is at room temperature.)

2. Good ductility to prevent brittle failure of the threaded sections of the grips either at the low temperature or room temperature.

3. A low thermal conductivity, especially at low temperatures, to restrict heat flow into the test chamber.

4. A low initial heat content to minimize the amount of heat to be extracted during the cool-down to test temperature.

5. Good corrosion resistance to prevent oxidation by condensed moisture when the apparatus is opened after each test. The close tolerance required for the sliding fit of the bottom grip necessitated this requirement.

The material finally selected for this application was Discaloy,[2] an iron-base austenitic alloy of the following composition: 25 per cent nickel, 13.3 per cent chromium, 2.75 per cent molybdenum, 2.25 per cent titanium, 0.81 per cent manganese, 0.72 per cent silicon, 0.07 per cent aluminum, 0.076 per cent carbon, and balance iron. This material has a high room-temperature yield strength (160,000 psi at 0.2 per cent offset) in the cold-worked and aged condition and retains its room-temperature ductility at low temperatures. The grip diameter then could be kept down to $\frac{1}{2}$ in. It is not notch sensitive and has a relatively low specific heat, equivalent to stainless steel. Combined with these aspects it has the highly desirable feature of low thermal conductivity at the low temperatures encountered. DeNobel (11) has found that minimum thermal conductivity is found in alloys of 26 per cent nickel, and reports data for an alloy very similar in composition to Discaloy.

Control and Measurement of Temperature

Because of the very small heat of vaporization of liquid helium it is not practical to place any flow regulating valves in the supply line, since these would represent major sources of direct heat leak and would cause premature vaporization of the refrigerant in the supply line. For this reason the flow of refrigerant is controlled by suitable regulation of the flow of helium gas being exhausted from the test chamber. In this manner the pressure differential between that imposed on the liquid in the storage Dewar (supply pressure) and the back pressure in the test chamber may be varied to obtain the desired flow.

The temperature control apparatus, shown schematically in Fig. 4, functions in the following manner: A supply pressure, usually 2 to 3 oz gage, is imposed on the surface of the liquid in the supply Dewar. The temperature controller is set at the desired signal for the predetermined temperature and the solenoid valve automatically opens. The manual valve on the exhaust manifold is also opened for rapid exhaust of the large volumes of warmed gas which are exhausted during the initial cool-down. Under these conditions the back pressure in the test chamber is essentially zero, and the pressure on the supply liquid causes the refrigerant to flow through the transfer line to the

[2] Trademark of Westinghouse Electric Corp.

test chamber. The refrigerant continues to flow at a fairly rapid rate as the chamber cools down. As the desired temperature is approached, the manual valve is closed, leaving only the small solenoid valve opened to exhaust. At this point the back pressure in the chamber builds up to 1 to 2 oz gage. The pressure differential now being less, the flow of refrigerant is retarded, thereby decreasing the cooling rate and preventing undesirable undershooting of the desired control temperature. When the predetermined test temperature is reached, the temperature controller-recorder, receiving a continuous signal from the thermocouple located on the test specimen, allows the solenoid valve to close. The pressure in the chamber immediately builds up to a value as great as that imposed on the supply Dewar and the flow of refrigerant stops. The heat leaking into the test chamber now causes the temperature to rise and the temperature controller activates the solenoid. With the solenoid valve again open the back pressure is relieved, and the helium again begins to flow, lowering the temperature in the chamber. The supply pressure may now be adjusted to produce the optimum on-off cycle of the solenoid valve. Sensitive pressure gages are installed at both supply and exhaust for visual observation. In this manner the maximum variation of temperature at any temperature level was ±2 F without any special adjustments being necessary. By closer adjustment of the supply pressure after the test temperature has been obtained, temperature fluctuations as small as ±0.5 F are achieved. This degree of temperature control is also maintained during actual tests when heat is being liberated by plastic deformation of the specimen. It is possible, however, that this degree of temperature control could not be maintained at extremely high rates of straining or when large discontinuous yields occur in the material being tested. Because of the particular arrangement of the refrigerant dispenser and temperature stabilizer, good uniformity of temperature distribution is attained. In no instances have temperature differences in excess of 2 F been observed over the 2-in. length of the test specimen.

In general, most of the low temperature-sensing devices available are either too bulky, too delicate to withstand the shock of the specimen rupturing, limited to a rather narrow temperature range, difficult to mount directly on test specimen, only applicable under static chamber conditions, or require too complex instrumentation for use in a remote control application. Thermocouples have the advantages of being small, easily fitted or adapted within the chamber, readily fastened directly to the test specimen, a relatively broad useful temperature range, and are convenient to use for remote control purposes. Copper-constantan thermocouples, with proper usage, provide the desired accuracy at low temperatures (**12, 13, 14**). A method of using copper-constantan thermocouples to provide reproducible measurements (±1 F) at temperatures as low as −452 F has been reported by Dauphinee (**14**). The major objections to the use of thermocouples as sensing elements at very low temperatures are the difficulty of measuring small changes in emf [$(dE/dT) \simeq 2.0$ (μv/deg Fahr) at −452 F] in a large total emf (6300 μv) and the lack of reproducibility. The decreased sensitivity is overcome by the employment of the sensitive instrumentation shown in Fig. 4. The thermocouple leads are run from the test sample to a constant temperature bath (ice bath using distilled water). A precision potentiometer is used to produce a bucking electromotive force (emf) of known amount (within 1 μv). The remaining (unbalanced) emf is fed to an amplifier which is calibrated directly with a fast responding continuous type temperature controller-recorder. An anticipatory type control unit is used in conjunction with the temperature controller to provide the utmost in constant temperature control. With the amplifier set on the most sensitive range, the full scale output of the controller-recorder represents only 50 μv. All leads and instruments are shielded against stray emf's. Lack of reproducibility is due to parasitic emf's arising from composition inhomogeneities and cold work in the parts of the wire that lie in a temperature gradient. Care can be exercised to check and select sections of wire which are homogenous, but it is difficult to avoid some cold working of the wire when mounting the couple on the test specimen. This may cause a slight change (up to 10 μv) in the measured emf for repeated tests at any given temperature; however, as reported by Dauphinee (**14**), it is found that the total difference in emf between any two fixed temperatures is always consistent within 1 μv. In this tension testing application, it was decided to work always with the difference in emf between the nitrogen and helium boiling points. Therefore, once a standard calibration has been determined for this temperature range, the unknown emf for a given temperature may be ascertained rather accurately by obtaining a reference check point in either liquid nitrogen or helium prior to each test and adding (or subtracting) the difference for the given temperature as indicated by the standard calibration. With this system it is possible to determine the actual test temperature within a maximum error of 2 F. With the use of a center zero amplifier and temperature controller, the emf for the desired temperature is set directly with the potentiometer, and the amplifier and controller then receives only the unbalance or difference between the actual and the desired emf. This arrangement then requires only one adjustment of one instrument, the K2 potentiometer, and enhances the simplicity and convenience of automatic temperature regulation.

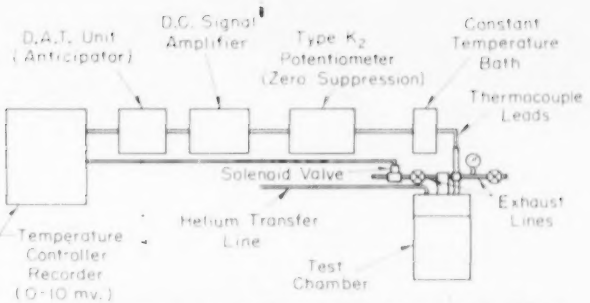

Fig. 4. Instrumentation for Temperature Control in the Range of −320 F to −452 F.

General Summary of Apparatus and Procedure

A photograph of the apparatus for tension testing in the temperature range of −320 to −452 F is shown in Fig. 5. Item *1* is a commercial 15-liter Dewar for the storage of liquid helium. The special tube used to transfer the helium from the storage Dewar to the test chamber is shown as Item *2*. Item *3* is a commercial 50-liter Dewar which is used to store and supply the liquid nitrogen cell (shield) of the test chamber. Item *4* is the test chamber. The constant strain rate tension testing machine is Item *5*, and its associated autographic stress-strain recorder is Item *6*. The load is measured using a commercial load cell, (accuracy, ±0.25 per cent of capacity) and strain is recorded by a direct mechanical linkage of the recorder's chart drive to the

test machine drive (crosshead movement). Plastic strains as small as 0.01 per cent can be determined from the autographic stress-strain curve. Item *7* is the low temperature controller-recorder. Item *8* is the pure bottled helium gas used to supply pressure over the liquid in the storage Dewar. A hydraulic jack used to adjust the helium storage Dewar to the desired level is Item *9*. Item *10* represents the instrumentation consisting of a potentiometer, a lead cell, a standard cell, a galvanometer, and the d-c amplifier. Items *11* and *12* are power supply panels and temperature controllers and recorders used with the tension testing machine for elevated temperature tests.

Refrigerant Consumption

In order to determine the practicability of the apparatus before purchasing and constructing the necessary equipment, it was necessary to estimate the helium consumption. The method of calculation (**3**) is only approximate since the available data are limited and the influence of some of the variables is indeterminate. There are three major sources of heat input into the system which were considered:

1. The initial heat content of the items to be cooled from −320 F (liquid nitrogen) to the test temperature: for example, the internal chamber components, the test machine grips and heads, and the test specimen.

2. The heat leaks inherent in the system: for example, the grip rods, the bottom chamber and lid interface, and the various entry wells.

3. The heat liberated during plastic deformation of a test specimen.

Considering these three items and assuming a test at −452 F of a high-strength ductile metal lasting 30 min including the cool-down period from −320 F to −452 F, the following results were obtained:

1. Initial heat content to be extracted = 1100 cal.

2. Heat leaks at −452 F = 44.5 cal per min (3.1 w).

3. Heat resulting from plastic deformation = 270 cal. This total heat contribution would result in a helium consumption of approximately 4-liters, assuming that only the acquisition of the heat of vaporization of the liquid is acting to remove heat from the system. Since many of the factors involved in heat transfer are unknown, it was difficult to approximate the benefit derived from the increased heat content of the gas at its exhaust temperature. However, it was felt that this aspect would considerably lessen the estimated helium consumption and would be especially beneficial at the higher test temperatures. For the purpose of comparison the heat of vaporization of helium is approximately 5 cal per g while the sensible heat of helium gas at room temperature is about 450 cal per g. A calculation in which the increasing enthalpy was taken into consideration, and in which a 50 per cent efficiency in heat transfer was assumed, approximated the helium consumption to be 1-liter for a test of 30 min duration at −382 F (43 K).

These results indicated that the described system for tension testing of relatively large tension test specimens (20,000 lb maximum load) in the temperature range of −320 to −452 F was practical and the system was built. This apparatus has been in use since November, 1954. The performance characteristics in terms of helium consumption and temperature control have been very gratifying. All values shown are averages for several tests made at the given temperatures and for tests of approximately 30 min duration including the cool-down period from nitrogen temperature (−320 F).

Test Temperature	Total Measured Helium Consumption, liters
−452 F (4.2 K)	2.0
−436 F (13 K)	1.25
−400 F (33 K)	0.90
−373 F (48 K)	0.75
−355 F (58 K)	0.60
−331 F (68 K)	0.50

The calculated values of helium consumption agree quite remarkably with the measured consumption. It is felt that the primary factor responsible for the difference between estimated and actual helium consumption was the unpredictable effect of the vapor in removing heat.

The measured values of refrigerant consumption vary somewhat from test to test depending on several factors. One factor which exerts considerable influence on the helium consumption in all tests is the helium required to make the initial cool-down of the transfer tubing from room temperature to helium temperature when it is first inserted into the helium supply Dewar and the refrigerant flow is started. This initial operation consumes about 200 ml of refrigerant which is included in the total consumption values previously listed. Occasionally, entrapped air is frozen in the transfer tube, necessitating a complete warm-up to room temperature and a second initial cooling of the transfer lines. Such difficulties are avoided by slowly lowering the transfer tube into the supply Dewar, thus permitting the initial flow of warmed helium gas to flush the air from the transfer line.

Another major factor which exerts considerable influence on the helium consumption is the rate of cooling-down from −320 F (nitrogen) to the test temperature. High rates of flow of refrigerant will permit the cool-down to be accomplished quite fast (1 to 2 min to reach −452 F). However, these fast cooling rates consume more helium and are not desirable since the cold vaporized gas is rapidly exhausted from the chamber before there has been much opportunity for heat transfer. It is found that a slower transfer rate (5 to 6 min to reach −452 F) provides sufficient time for heat exchange and appreciably lessens the helium consumption. Specimens are held at the low temperature for 8 to 10 min prior to starting the test.

Fig. 5.—Apparatus for Tension Testing in the Temperature of −320 F to −452 F.

A less significant factor found to influence helium consumption is the magnitude of the vacuum in the cells of the test chamber. Initially the chamber cells are evacuated and sealed off at about 1 μ pressure. After many tests the vacuum becomes somewhat poorer because of some degassing in the vacuum cells and small leaks which occasionally develop due to shock imparted to the chamber when the specimens rupture. Only a very small difference in total helium consumption is observed between the two conditions of vacuum. The reason that this is not a serious problem is no doubt largely due to the fact that a relatively poor vacuum at nitrogen temperature (−320 F) is greatly improved at helium temperature (−452 F) because in the process of reducing the temperature the helium refrigerant also freezes out the gases that have leaked into the vacuum cell. As a precaution against total vacuum failure causing excessive consumption of refrigerant the chamber is leak checked and evacuated periodically, usually after every 12 to 15 tests. It is felt that a dynamic vacuum system would serve as well as the static system just described.

The consumption of nitrogen used as a shield in the test chamber is relatively high as compared to the helium used. The average test consumes about 25 to 30 liters of nitrogen with a steady flow maintained through the nitrogen cell of the chamber at all times. Nitrogen is available in large quantities at a low cost while the helium supply is limited and costs about 100 times as much per liter. For this reason the major emphasis is to conserve on helium. It is felt that the nitrogen consumption could be improved by using a controlled nitrogen flow system (2) instead of a steady flow. Nitrogen consumption could also be lessened considerably by the installation of a thin walled tube with an external valve to provide a means of draining the inner cell of the test chamber. This would permit the precooling of the inner portion of the test chamber by direct addition of liquid nitrogen which could be drained off just prior to admitting the helium to the chamber. The presence of a large quantity of liquid nitrogen in the inner chamber is very undesirable, for considerable quantities of helium would be used just to cool the nitrogen. The present apparatus does not have this feature and depends mainly on radiation and conduction to the nitrogen cell to precool the inner chamber and its components. The present precool (to −320 F) time of 2 hr could probably be cut to 15 to 30 min with the addition of such a feature.

Discussion of Applications

The development of this apparatus, which when coupled with previous equipment (2) facilitates tension testing at any temperature in the range from room temperature to −452 F (4.2 K), will greatly enhance the opportunity to acquire a better understanding of the factors which determine the strength of materials. One aspect—unexpected brittle failure—is a serious problem to the nation as a whole. Before we can make any major contribution towards predicting and avoiding these failures and towards the development of suitable materials and designs that are not susceptible to brittle behavior, we must first acquire some basic understanding of the nature and mechanism of the problem. We must isolate, study, and understand the influence of the various mechanical and metallurgical variables on the factors which promote or retard brittle behavior. The low-temperature tension test is the key tool in such studies in that at these low temperatures, controlled brittle behavior can be produced and quantitative measurements of the stresses and strains involved can be made.

In the short time that this apparatus has been in operation, considerable progress has been made in our understanding of the fundamental rheological properties of metals. Of noteworthy interest is the observation (15) that metals of various lattice structures all appear to deform plastically in a similar fashion at −452 F. Samples of nickel, zirconium, beta brass, and quenched-and-tempered alloy steel (SAE 4340 type) have been found to exhibit considerable ductility at −452 F (4.2 K), the deformation taking place in the form of a prolonged series of sudden discontinuous yields. Of more practical interest is the observation that, based on quantitative measurements (15), annealed or normalized hypoeutectoid steels are much more susceptible to brittle failure than quenched-and-tempered steels of the same general composition. Considerable work of this nature is under way, utilizing the apparatus described in this paper.

Conclusions

The refrigeration chamber and procedure for low-temperature tension testing described in this paper represent new and useful developments in the field of mechanical testing, and further represent an improvement over existing systems and eliminate the gaps that were present between attainable test temperatures. The vaporized refrigerant conveniently serves as the testing medium and thereby eliminates the undesirable effects (2,16,17) of testing in liquid media. Temperatures in the range from −320 to −452 F are reached and stabilized quite quickly, conveniently, and accurately with an automatic control and recording system. The apparatus is relatively small, simple, and economical to operate. Finally, it is concluded that rather accurate predictions of helium consumption for this type of application can be made with proper consideration of all the factors.

Acknowledgment:

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Relaxation of High-Tensile-Strength Steel Wire for Use in Prestressed Concrete

By Garnett McLean and C. P. Siess

PRESTRESSED concrete is a practical method of construction only because the loss in prestress with time due to concrete creep and shrinkage approaches some limiting value; it can be an economic method only if this loss is a relatively small percentage of the initial prestress. This condition is obtained by using high tensile strength steel, initially stressed to 60 to 70 per cent of its ultimate strength. At such stresses, however, this steel, while under constant strain, suffers a relaxation of stress; this phenomenon of stress relaxation at constant strain is comparable to creep, which is the increase in strain which occurs in materials subjected to a constant stress. It is necessary in the design of prestressed concrete members to know, at least approximately, how much steel relaxation will occur during the life of the structure.

Relaxation tests were made to investigate the effects of (*a*) type of wire, (*b*) stress level, and (*c*) preliminary overstressing.

All tests were made on hard-drawn wire manufactured by the American Steel and Wire Division of the United States Steel Corp. All of the wire tested had been either straightened or stress-relieved, or both, after drawing; no tests were made on wire in the as-drawn state. The various types of treatment after drawing are designated by the use of the letters *S* to represent straightening and *R* to represent stress-relieving, as follows:

Type *SO* wire was straightened but not stress-relieved.

Type *SR* wire was straightened and subsequently stress-relieved.

Type *OR* wire was not straightened but was stress-relieved.

Relaxation characteristics were obtained by using resonant frequency measurements to determine stress variation with time.

Relaxation tests on wires of types *OR*, *SR*, and *SO* were carried out from initial stresses of 50 to 80 per cent of the ultimate strength of the wire. The duration of the majority of the tests was about 1000 hr, but some were extended to 7000 hr.

A number of the type *OR* wires were subjected to a preliminary period of over-stressing at a stress approximately 10 per cent above that from which the relaxation was subsequently measured. This series of tests was initiated because of the recommendations that have been made by various individuals and organizations which imply that temporary overstressing for a short period greatly reduces the loss in stress due to relaxation.

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GARNETT McLEAN carried out the work described in this paper while a Research Assistant at the University of Illinois. He has since returned to England where he is associated with the firm of Peter Lind and Co., Ltd.

C. P. SIESS, Research Professor of Civil Engineering at the University of Illinois, has been engaged in research on highway bridges and reinforced concrete for the past 14 years.

Properties of Hard-Drawn Steel Wire

The most commonly available and most comprehensive piece of information on the properties of cold-drawn wire is the stress-strain relationship. It is natural, therefore, that attempts have been made to interpret all aspects of the physical behavior of the wire in terms of this relationship. Of primary interest to the designer in prestressed concrete are the following characteristics: (*a*) modulus of elasticity, (*b*) tensile strength, (*c*) ductility, and (*d*) relaxation loss. The first two are readily obtainable from the stress-strain curve; ductility requires some consideration of yield strength. Relaxation loss is not obviously deducible from this information. Guyon (**1**),[1] however, has used an empirical expression for the relaxation loss as a function of the slope of the curve at the initial tensioning stress employed.

Because hard-drawn wire has no definite yield point, various conventions are employed to define the shape of the stress-strain curve to the region of yield. This region includes initial stress levels commonly employed in prestressed concrete. Bannister (**2**) recommends that the yield strength be defined by the stress at 0.7 per cent elongation; this method has the disadvantage that a knowledge of the stress at zero strain in the test is presupposed. The stress corresponding to 0.2 per cent permanent set is also frequently used to define the yield characteristics, and is used in this report.

A typical stress-strain curve for as-drawn wire is shown in Fig. 1. This curve is noteworthy for the relatively small range of stress in which Hooke's law is at all applicable, and also for the complete absence of any yield point.

When drawn wire is coiled directly from the wire drawing block, it acquires a permanent curvature of about 12-in. radius, and is subsequently shipped in coils of about 2-ft diameter. Because of its high degree of curvature, this wire is inconvenient to use. Therefore, it is commonly mechanically straightened; the effects of straightening can be observed in the appropriate stress-strain curve in Fig. 1. It should be noted that although straightening increases the total elongation of the wire, it further decreases its elastic properties.

Controlled low-temperature heat treatment has been employed by wire manufacturers to increase the elastic range of as-drawn wires (**3,4**). This treatment is variously known as stress-relieving, or strain-aging. It is a continuous process in which the wire is pulled through a lead bath at temperatures of 750 to 800 F for a few seconds. Its effect on the elastic properties of the wire can be seen in Fig. 1; there is a notable increase in the total elongation of the wire before fracture.

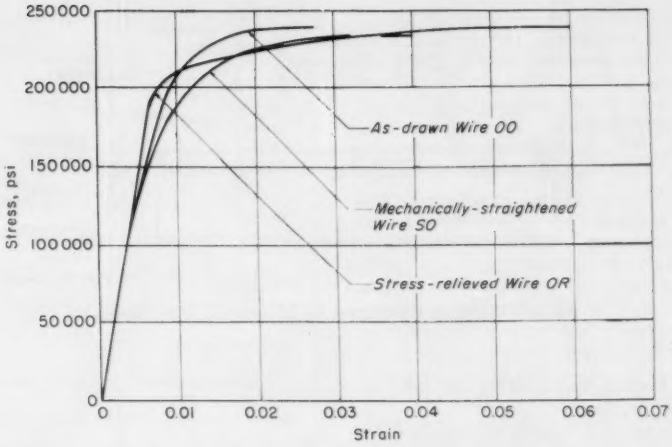

Fig. 1.—Stress-Strain Curves of Cold-Drawn Wire.

The stress-relieving treatment is carried out on equipment having large diameter reels, and hence stress-relieved wire has much less curvature than wire coiled directly from the wire-drawing block; the free radius of this wire, when shipped in 5-ft diameter coils, is about 3 ft. This is an added advantage to the prestressing engineer, as further straightening is unnecessary.

The important changes in the properties of the wire, resulting from the heat treatment, include a change in the loss of stress due to relaxation. Changes in relaxation loss resulting from the various manufacturing processes, and their relation to these processes, are of primary interest in this study.

Measurement of Relaxation

A considerable amount of experimental work on creep and relaxation of high-tensile steels at room temperatures has been carried out in recent years. The greater portion of this work has been devoted to creep, at least partly because creep tests are simpler to perform than relaxation tests. However, the working conditions for steel in prestressed concrete are such that relaxation is much more important than creep, and since no clear relation between the creep and relaxation characteristics of high-tensile steel has been found, the value of the available creep data is limited.

Three types of tests have been employed in the measurement of the relaxation of high tensile strength wires:

(*a*) Lengths of wire up to 100 ft have been stretched and the stress observed at intervals by temporarily balancing the load at one end. This method has the advantage that, because of the great length of wire under load, any losses due to slippage in the anchorages are negligible. Tests of this general type have been reported by Magnel (**5**) G. T Spare (**6**) and Clarke and Walley (**7**).

(*b*) Short lengths of wire have been kept under load in a testing machine, and the load adjusted periodically to maintain the length constant. Bannister (**2**) and others have made tests of this type.

(*c*) The third type of test comprises those in which a relatively short length of wire is stretched between fixed anchorages, and the stress in the wire is subsequently measured by employing one of the properties of a stretched string. Dawance (**8**) measured the stress, in his tests at the Building and Public Works Laboratory in Paris, by observing the frequency of the wire in lateral vibration, the stress being proportional to the square of this frequency. Gifford (**9**), at Imperial College, London, measured the wire tension by observing the lateral deflection resulting from a small known load applied at the center.

The Vibration Method

The vibration technique employed by Dawance (**8**) in his relaxation tests in Paris appeared to have the important advantages in that it required a comparatively small amount of space and did not require the continuous use of a testing machine. For these reasons,

[1] The boldface numbers in parentheses refer to the list of references appended to this paper.

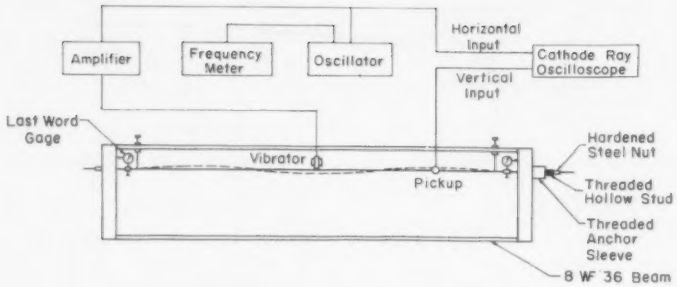

Fig. 2.—Vibration Equipment for Measuring Wire Stress.

this method was used in the tests reported herein.

The method depends essentially upon the following relationship between the natural frequency of lateral vibration of a stretched string and the tension in the string:

$$f' = \frac{1}{2L}\sqrt{\frac{Tg}{w}} \quad \ldots\ldots\ldots(1)$$

where:

f' = the natural frequency of lateral vibration,
L = the length of string between nodes,
T = the stress in psi,
w = weight per unit length of wire, and
g = the acceleration of gravity.

For a steel wire, which has bending stiffness, a correction must be made for this stiffness according to the equation;

$$f^2 = f_1^2 + f'^2 \ldots\ldots\ldots(2)$$

where f is the natural frequency of the stretched wire, f' is the natural frequency neglecting bending stiffness, as in Eq 1, and f_1 is the natural frequency of the wire when considered as a simply-supported beam, untensioned, on two supports a distance L apart:

$$f_1 = \frac{\pi}{2L^2}\sqrt{\frac{EI}{\mu}} \quad \ldots\ldots\ldots(3)$$

where μ is the mass per unit length of the wire. Equation 2 is an approximation and is applicable only when the stiffness of the wire is small. Hence:

$$f'^2 = \frac{1}{4}\frac{Tg}{L^2 w} \ldots\text{(from Eq 1)}$$

$$f'^2 = f^2 - \frac{\pi^2}{4}\frac{EIg}{L^4 w} \ldots\text{(from Eqs 2 and 3)}$$

Therefore:

$$T = \frac{4wL^2}{g}(f^2 - K_1)$$

where $K_1 = \pi^2 EIg/4L^4 w$ and, for a particular diameter wire, depends only on the distance between the nodal points.

In practice, owing to lack of absolute rigidity of the testing frame:

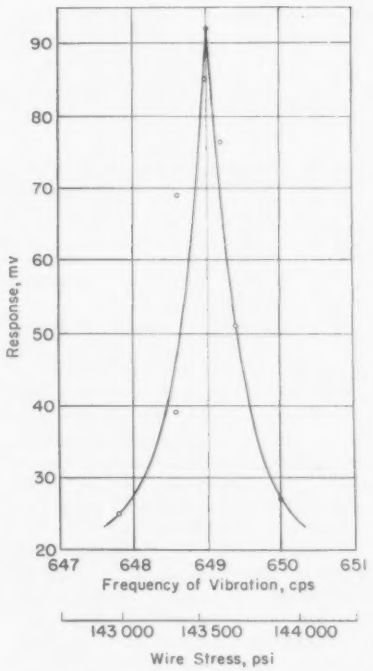

Fig. 3.—Frequency-Response Curve.

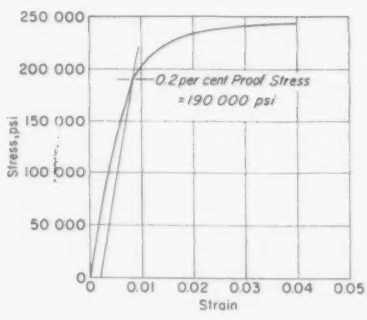

Fig. 4.—Stress-Strain Curve of Type *SO* Wire.

$$T = \frac{4wL^2}{g}(f^2 - K_1 - K_2) \ldots\ldots(4)$$

where K_2 is a constant of the test frame and mode of vibration. This relationship enables the stress in a stretched wire to be computed from an experimentally obtained value of the natural frequency of lateral vibration of the wire. However, since the constant K_2 could not be evaluated, the use of Eq 4 was avoided by determining the relation between T and f experimentally for each wire prior to the relaxation test, as described subsequently.

Test Equipment

Test frames consisted of 3-ft lengths of 8 by 8-in. wide-flange beam sections with heavy plates welded across the ends as shown in Fig. 2. In each frame, the end plates were drilled to accommodate four wires stretched between them. Quarter-inch screws, mounted in holes drilled and tapped in the beam flanges and adjusted so as to bear against the stretched wires, provided definite nodal points when the wires were vibrated.

Both threaded and split conical wedge anchorages were employed. In the former a hardened steel nut was turned up as far as possible on a thread cut on the wire; this anchorage could be relied upon to develop only about 70 per cent of the tensile strength of the wire. For higher stresses an improved anchorage was required. A grip was developed that incorporated the three hardened tapered wedges from a commercial 6 BSG-size Strandvise grip, bearing on an internally tapered stud. This grip was successfully used in the tests that commenced at the higher stress levels. Because wedge-type grips necessarily suffer from pull-in effects, light Last-Word dial gages were mounted on the test wires so that they indicated any movement of the wire in the grip relative to the end plate of the test frame.

Wires were stressed individually by a center-hole hydraulic jack. A dynamometer utilizing four *SR*-4 electric resistance strain gages was incorporated in the pull rod of the jack; the gages, when connected to a Baldwin Portable Strain Indicator, enabled the strain in the dynamometer to be observed.

The dynamometer was calibrated in a testing machine for loads up to 7000 lb, corresponding to a stress of over 240,000 psi in a 0.192-in. diameter wire. The dynamometer thus gave the stress in the wire directly during the period of stressing.

The electrical apparatus employed to vibrate the wire, to observe resonant vibration of the wire, and to measure

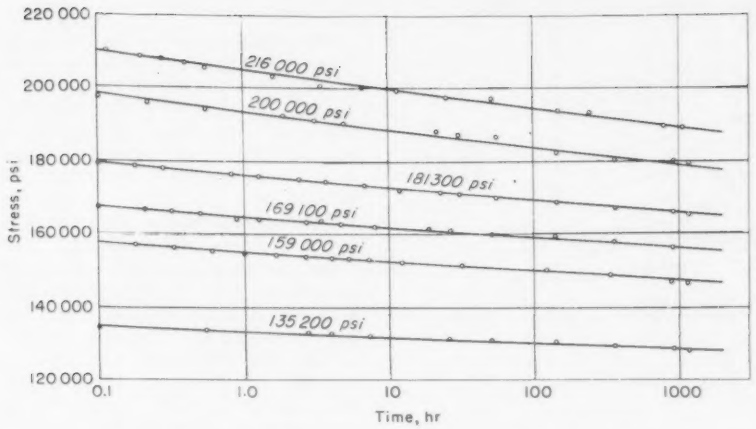

Fig. 5.—Relaxation of Straightened Hard Drawn Wire, Type *SO*.

the frequency of vibration, is shown diagrammatically in Fig. 2. The main components were as follows:

1. An oscillator, with variable frequency output.
2. A frequency counter which counted the number of cycles in 10 sec of the oscillator output, and hence gave the oscillator frequency correct to $\frac{1}{10}$ cps.
3. An electromagnetic vibrator, fed by the oscillator through a variable-output amplifier. The vibrator was mounted about $\frac{1}{32}$ in. away from the wire, at its midpoint.
4. An ear-phone, also mounted close to the wire, to pick up the forced vibration of the wire.
5. A cathode-ray oscilloscope; the output of the oscillator was fed directly into the horizontal deflecting plates, and the current generated in the ear-phone by the vibrating wire was fed into the vertical deflecting plates.

When the oscillator frequency coincided with the natural frequency of the wire, a figure eight-type Lissajou picture was obtained on the oscilloscope. The picture was of this form because the wire made one complete oscillation for both the positive and negative half-cycles of the driving current. The third mode of vibration of the wire was employed, for two reasons: (1) it reduced the effects of uncertainties regarding the end conditions of the wires, and (2) it raised the resonant frequency of the wire to a pitch at which it was audible, and hence could be located approximately by ear. Thus the resonant position was indicated by: (*a*) sound, (*b*) appearance of a Lissajou figure on the oscilloscope, and (*c*) maximum vertical dimension of the figure on the oscilloscope.

The vertical dimension of the oscilloscope figure increased greatly at resonance, necessitating reduction in the amplification of the oscillator output. The maximum vertical size of the oscilloscope figure was the criterion employed in determining the precise position of resonance.

Test Procedure

The procedure for tensioning a wire was as follows: The wire was stretched by the hydraulic jack in about five increments of load, up to the required initial stress. At each step the wire was vibrated and the oscillator frequency adjusted until the resonant frequency of the wire was obtained; this frequency, as indicated by the frequency counter, was noted. The strain indicator was balanced, and thus the strain in the dynamometer, and hence the stress in the wire was also obtained. From these observations made during the stressing of the wire, a calibration curve of stress against the square of the frequency was obtained, thus making it unnecessary to evaluate the constants K_1 and K_2 in Eq 4. When the required stress was reached, a threaded anchoring sleeve was turned up to bear hard against the end-plate of the testing frame. The pressure in the jack was then released, and the wire vibrated immediately to obtain the resonant frequency. The corresponding stress found from the calibration graph was the initial stress level of the relaxation test. In the case of wires anchored in wedge grips, the dial gages mounted at the ends of the wire were also adjusted immediately after the release of the jack pressure. The wire was subsequently vibrated after suitable intervals of time, and the resonant frequency and the dial gage readings (if any) were noted. Several readings were taken in the first hour of the test and later at greater intervals, in accordance with the early rapid, and later less rapid, rate of relaxation.

The dial gages indicated relative movements between the ends of the wires and the end-plates of the frame. In the case of the threaded wires, this movement was equivalent to a stress loss in the wire of about 200 psi and has been neglected. The relative movements in the case of wires anchored by wedge grips were considerably larger and were therefore compensated for in the computations of stress after relaxation; to the stress obtained from the frequency measurement was added the relative movement multiplied by the modulus of elasticity of the steel.

The accuracy of the tests is limited initially by the accuracy of the dynamometer calibration, namely, about 5 lb. This is equivalent to approximately 170 psi in the 0.192-in. wire. The accuracy of the measurement of stress by the vibration procedure was checked by connecting a vacuum-tube voltmeter across the ear-phone output

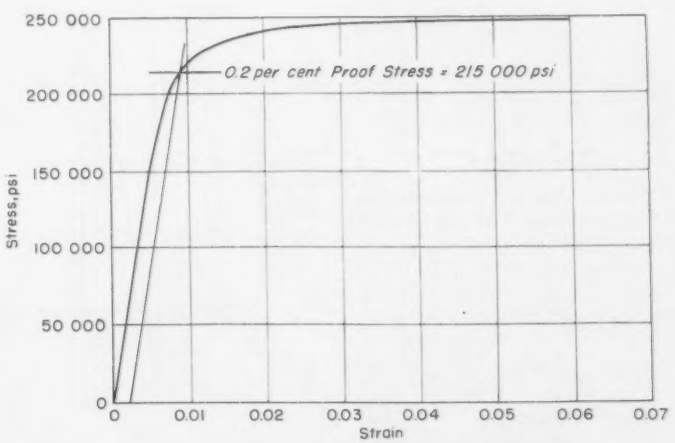

Fig. 6.—Stress-Strain Curve of Type *SR* Wire.

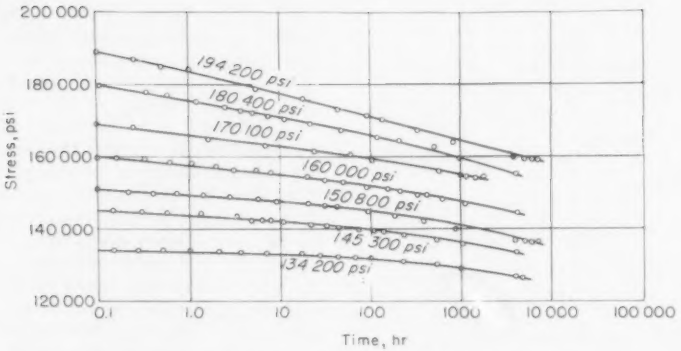

Fig. 7.—Relaxation of Straightened and Stress-Relieved Wire, Type *SR*.

and observing the magnitude of the response at frequencies in the neighborhood of resonance. The results are shown in Fig. 3, from which it appears that accuracy is about 100 psi. The tests were performed in an area where the temperature range was fairly large; it is considered, however, that this should not have had any great effect, as the wires were stressed against a steel frame undergoing the same temperature range. Inaccuracies due to temperature changes could apparently have resulted only from rapid changes that occurred immediately prior to the measurement of stress. However, the actual degree of accuracy obtained in the measurements may be better judged from the graphs of the results.

Results of Tests

Results are presented for four series of tests as outlined in Table 1. The initial stress was the main variable in each series. Series 1, 2, and 3 were for the purpose of observing the effect of different manufacturing processes on the relaxation characteristics of the wire. In Series 4 the wires were overstressed approximately 10 per cent above the intended initial stress for a period of 15 min prior to the commencement of the test. The effect of initial overstressing is indicated by comparison of the results with those of Series 3.

Properties of Wire Tested

All the hard-drawn wire tested was made from basic open-hearth steel of the following analysis range:

Carbon, per cent	0.75 to 0.86
Manganese, per cent	0.50 to 0.90
Phosphorus, max, per cent	0.045
Sulfur, max, per cent	0.050

The as-drawn wire was subsequently treated as follows: Wire *SO* was mechanically straightened. Wire *OR* was stress-relieved in a continuous process, and supplied in 5-ft diameter coils. Wire *SR* was straightened, cut into 15-ft lengths, and then stress-relieved. Stress-relieving was carried out in hot lead at about 800 *F* for a period of between 5 and 15 sec.

Nominal diameter of the wire was 0.192 in.; actual diameters ranged from 0.192 to 0.194 in. Wire stresses reported were calculated on the basis of actual diameters. Stress-strain curves for the four types of wire are given in Figs. 4, 6, 8, and 10.

Test Results

The results for each series of tests are presented graphically as: (*a*) stress plotted *versus* the logarithm of time, in Figs. 5, 7, 9, 11, and 13; (*b*) initial wire stress, as a percentage of the tensile strength, plotted against the percentage loss in stress at 1000 hr in Figs. 12 and 14.

The semilogarithmic plots of type (*a*) demonstrate the apparently continuing nature of relaxation. The plots of type (*b*) show, for all types of wire tested, that the percentage relaxation loss increases with increase in the initial stress. It would of course be desirable to obtain an empirical relationship from which, knowing some wire property, the relaxation loss from any given initial stress could be calculated. Various methods of plotting the results of all the tests in order to obtain such a general relationship were attempted, but without success.

Discussion of Test Results

The 28 tests for which results are reported represent an exploratory investigation involving four different types of wire, various levels of stress, and the effects of initial overstressing. Most

TABLE I.--OUTLINE OF TESTS.

Series	Number of Tests	Type of Wire	Properties of Wire			Range of Initial Stress, psi
			Strength, psi	0.1 per cent Proof Stress, psi	0.2 per cent Proof Stress, psi	
No. 1....	6	*SO*	244 000	150 000	190 000	135 200 to 216 000
No. 2....	7	*SR*	240 000	201 000	208 000	134 200 to 194 200
No. 3....	2	*OR*-1	250 000	206 000	215 000	146 000 to 170 000
	5	*OR*-2	266 000	218 000	237 000	136 100 to 186 500
No. 4....	8	*OR*-2	266 000	218 000	237 000	142 700 to 209 000

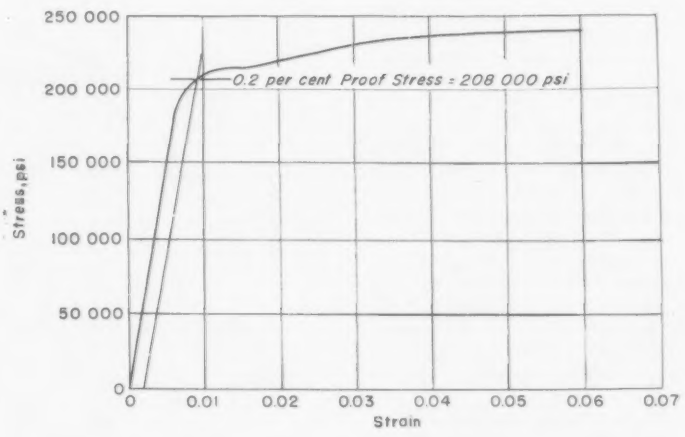

Fig. 8.—Stress-Strain Curve of Type *OR*-1 Wire.

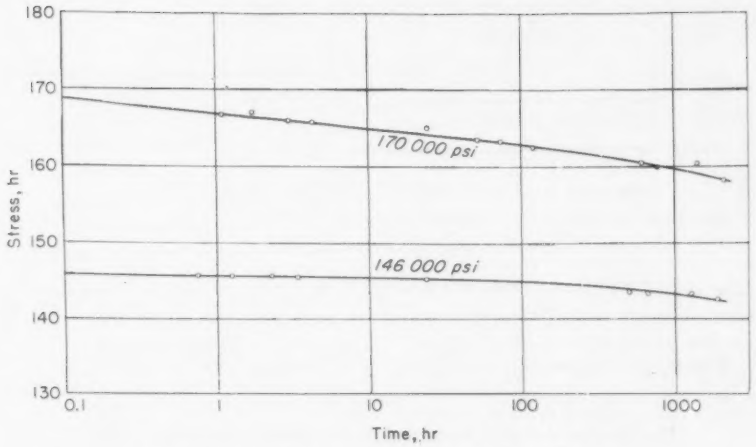

Fig. 9.—Relaxation of Stress-Relieved Wire, Type *OR*-1.

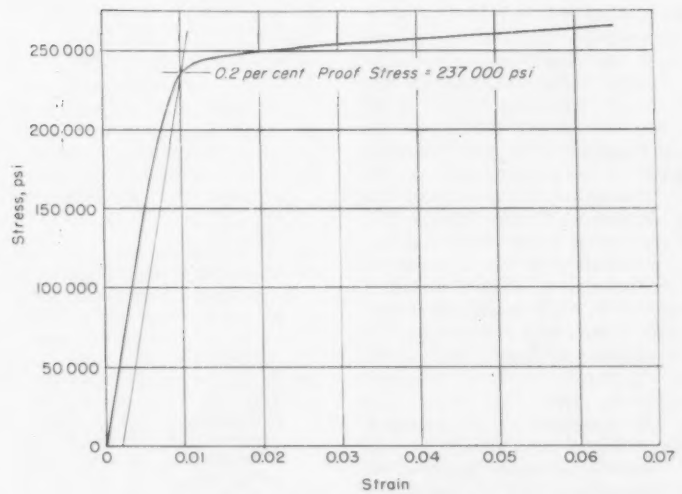

Fig. 10.—Stress-Strain Curve of Type *OR*-2 Wire.

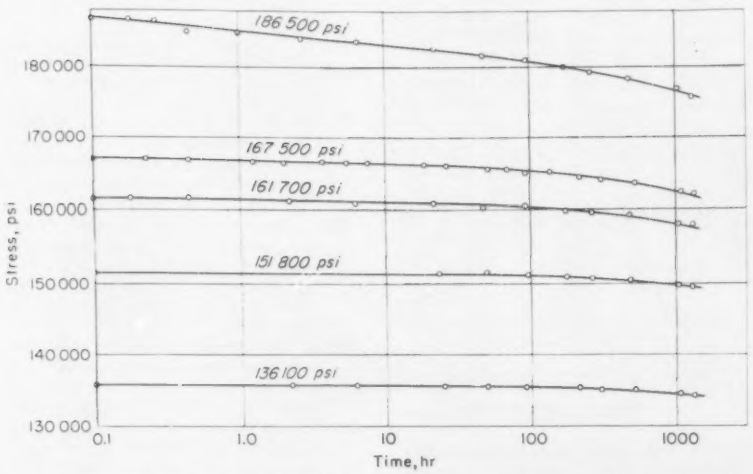

Fig. 11.—Relaxation of Stress-Relieved Wire, Type *OR*-2.

of the tests have been carried only a little beyond 1000 hr, and the discussions which follow are based primarily on comparisons at this early stage. For these reasons, no conclusions relating to the performance of these wires in service can or should be drawn as a result of the limited data available. It is possible, however, to point out certain trends which seem to be indicated by the results presented herein.

(*a*) *Curvature of Semilogarithmic Plots.*—It can be observed that the semilogarithmic plots of stress *versus* time for wire types *SR*, *OR*-1, and *OR*-2, in Figs. 7, 9, 11, and 13, all show a clearly defined downward curvature. A similar effect was noted by De Strycker (**10**) who found that heat-treated wires showed a curvature from the very beginning of the test, whereas deviation from a straight line could be perceived only after several days for hard-drawn wires. The semilogarithmic plot for type *SO* wire in Fig. 5 is a straight line up to 1000 hr. However, readings made at 5000 hr have shown a downward curvature in this case also. It should be pointed out that although this curvature on semilogarithmic plots precludes linear extrapolation to longer relaxation periods, it does not necessarily imply that losses will become excessive within any reasonable length of time.

(*b*) *Effect of Straightening.*—No as-drawn wire was tested because the large initial curvature of this wire prevented it from being introduced into the testing frame without some prior straightening. Hence, the effect of straightening can be considered only by comparisons of the stress-relieved wires *OR* and *SR*. From the curves in Fig. 12 it is seen that the relaxation losses at 1000 hr were roughly twice as great for the *SR* wire as for the *OR* wire when stressed to the same percentage of the tensile strength.

(*c*) *Effect of Stress-Relieving.*—Since no as-drawn wire was tested, the comparisons are limited to the straightened wires *SO* and *SR*. The curves in Fig. 12 show little difference in 1000-hr losses for *SO* and *SR* wire until the stress exceeds about 70 per cent of the ultimate. At higher stresses, the losses are significantly greater for the stress-relieved wire.

(*d*) *Comparison of Types OR-1 and OR-2.*—The wires designated as *OR*-1 and *OR*-2 represent two separate shipments of the same commercial product. The chemical analyses for the two wires differed slightly but both were within the manufacturer's range of tolerance. Their physical properties differed somewhat, as is shown by the stress-strain curves in Figs. 8 and 10; the tensile

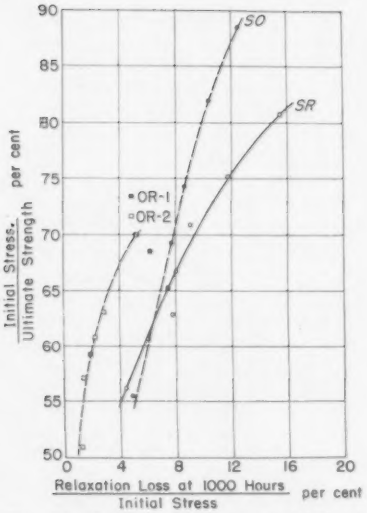

Fig. 12.—**Relaxation Loss at 1000 hr versus Stress Level.**

strength, the 0.2 per cent proof stress, and the ratio of proof stress to ultimate were all higher for *OR*-2 than for *OR*-1. Since only two tests were made on type *OR*-1 wire, it is not possible to make significant comparisons between the relaxation characteristics of the two shipments of commercially similar wire.

(*e*) *Effect of Initial Overstressing.*—The losses at 1000 hr for type *OR*-2 wire tested in series 3, without overstressing, and in series 4, with overstressing, are plotted in Fig. 14 for comparison. For initial stresses in the range from 50 to 65 per cent of the tensile strength, overstressing appears to have little effect; the difference in percentage relaxation loss at any given stress level in this range is no greater than the observed scatter of the test results. However, at higher stresses, the effect of overstressing in reducing the 1000 hr losses becomes more apparent. At an initial stress of 70 per cent of the ultimate, the 1000-hr loss is about 3.6 per cent for the overstressed wire as compared to about 5.2 per cent for the wire not initially overstressed. However, caution should be exercised in any attempt to extrapolate these comparisons to longer periods of relaxation.

Summary

The object of this paper has been: (1) to describe a test method for measuring the relaxation of highly stressed steel wires; (2) to present typical results obtained from exploratory tests on 28 specimens of four types of wire. The discussion of the results of the tests must be considered qualified by the limited scope of the tests and especially by the relatively short relaxation times involved.

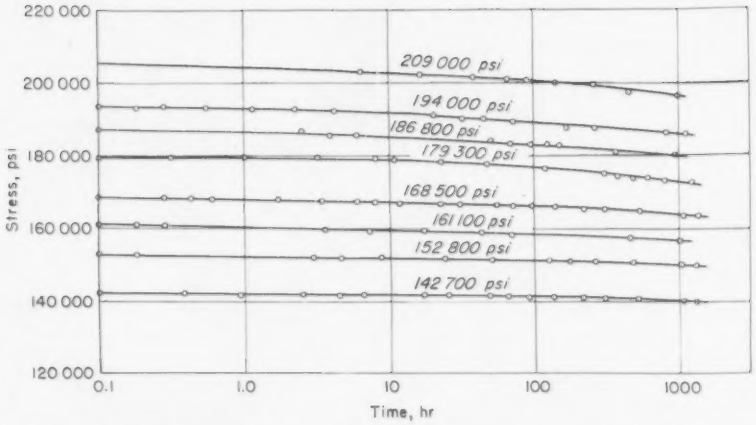

Fig. 13.—**Relaxation of Preliminarily Overstressed Wire, Type *OR*-2.**

Acknowledgment:

The studies reported in this paper were made in connection with an investigation of prestressed concrete for highway bridges being conducted by the Engineering Experiment Station of the University of Illinois as part of the Illinois Cooperative Highway Research Program in cooperation with the Illinois Division of Highways and the U. S. Bureau of Public Roads. The tests were made in the Structural Research Laboratory of the Department of Civil Engineering, under the general direction of N. M. Newmark, Research Professor of Structural Engineering.

The authors are deeply indebted to J. H. Appleton, formerly Research Associate in Civil Engineering, for many helpful suggestions and continued assistance throughout the work, and to N. A. Gouvis, Research Assistant in Civil Engineering, for his assistance with the tests.

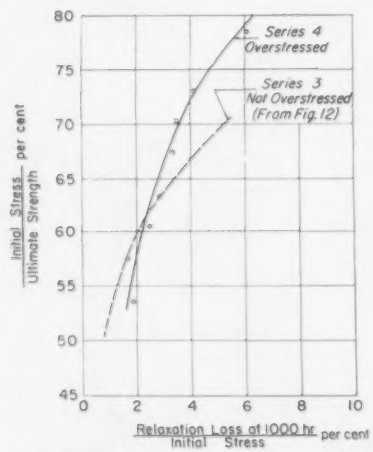

Fig. 14.—**Relaxation Loss of Preliminarily Overstressed Wire Type *OR*-2, versus Stress Level.**

This paper is based on an M. S. thesis prepared by G. McLean under the direction of C. P. Siess.

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An Axial Loading Creep Machine*

By M. H. Jones and W. F. Brown Jr.

Factors influencing the eccentricity of loading in tension testing, and a creep machine designed to reduce bending stresses in tension creep to a minimum.

To MINIMIZE variability of results in elevated-temperature tension tests, rather detailed standards have been set up outlining the accuracy required of the load-measuring equipment, the design of specimen, as well as the permissible deviations in temperature and temperature distribution over the gage length. Another factor which can influence reproducibility of results obtained in either short-time tension tests or in creep tests is misalignment between the axis of load application and the longitudinal axis of the specimen, generally referred to as "eccentricity."

Eccentricity of loading results in a bending stress being superimposed on the tensile stress. The eccentricity present at the start of a test will progressively decrease with increasing applied load owing to elastic deflections in the specimen and in the loading rods. If a sufficient amount of plastic flow occurs in the specimen, it will align itself and eliminate the bending stress.

From the foregoing it is evident that eccentricity will influence the results when the test involves elastic or small plastic strains. In the presence of eccentricity, the stress calculated from the applied load and the specimen area will be an average value lower than the maximum surface stress. Thus the apparent strength of a relatively brittle material will be reduced because of eccentric loading. For a given eccentricity, the reduction in strength will be greater, the lower the ductility of the material. However, it is not possible to assign a lower limit, independent of material and testing conditions, to the amount of plastic flow which must occur before the effects of a given eccentricity may be neglected.

The problem of reduction of eccentricity in both tension and creep tests is becoming increasingly important. Materials of current engineering interest for gas turbines and other severe service applications very often possess high strength but extremely limited ductility. In addition, notch tests are receiving wide interest, and it has been shown (1,2,3)[1] that materials normally ductile may exhibit brittle behavior in such tests. These facts are well recognized, and special laboratory procedures have been developed (4,5,6) to conduct specific tests with a minimum amount of eccentricity. None of these developments, however, is particularly adaptable to routine tension or creep testing.

This paper discusses the limitations of some of the standard methods presently in use to reduce eccentricity in tension loading. It also describes the design features of a new creep machine, which incorporates loading fixtures that are suitable for conducting routine tests and that provide very low eccentricities of loading. In addition, the new machine possesses several other advantages of general construction and temperature control circuitry.

Standard Tension Loading Methods

The ASTM has established standards for the tension testing of metallic materials at both room and elevated temperatures and also for the creep testing of metallic materials, Methods E 8,[2] E 21,[3] and E 22,[4] respectively. In these standards, attention is called to the importance of avoiding eccentricity. While no recommendations are given regarding the amount of misalignment permissible, according to Methods E 8, a 16 per cent increase in surface stress occurs if a standard 0.253-in. diameter specimen is loaded with an eccentricity of 0.005 in.

Recommended Practice E 21 states that each specimen when set up should be examined for faulty alignment and suggests that the eccentricity can often be detected by elastic extension measurements taken before the test on opposite sides of the specimen. Eccentricity is said to be indicated by unequal strain readings on the two extensometers. Unfortunately, this procedure will not indicate the presence of eccentricity when the gages are located in a plane perpendicular to the bending plane.[5] Furthermore, if the two diametrically opposite gages are not located in the bending plane, the strain readings will indicate an eccentricity less than the true value. In order to determine the true value of eccentricity and the magnitude of the bending stresses, four gage locations are preferred (see Appendix I).

The ASTM does not specify particular gripping devices for elevated temperature testing in either Recommended Practice E 21 or E 22, except to suggest

[1] The boldface numbers in parentheses refer to the list of references appended to this paper.

[2] Tentative Methods of Tension Testing of Metallic Materials (E 8–54 T), 1954 Supplement to Book of ASTM Standards, Part 1, p. 550; Part 2, p. 388.

[3] Recommended Practice for Short-Time Elevated-Temperature Tension Tests of Metallic Materials (E 21–43), 1952 Book of ASTM Standards, Part 1, p. 1438.

[4] Recommended Practice for Conducting Long-Time High-Temperature Tension Tests of Metallic Materials (E 22–41), 1952 Book of ASTM Standards, Part 1, p. 1445.

[5] The bending plane is defined as that plane containing the fibers of maximum and minimum stress.

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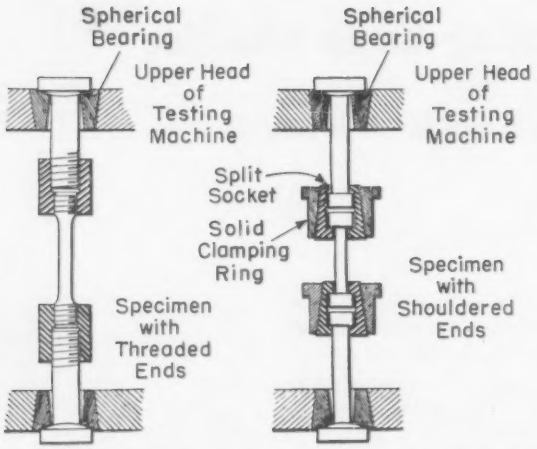


Fig. 1.—ASTM Tension Loading Fixtures Recommended in Methods E 8–54 T.

that rods or cables of the greatest length possible be used. For room-temperature tension testing, Methods E 8 recommend the use of the devices shown in Fig. 1, but no tolerances or fits between the various parts are indicated. Alignment is presumably brought about by movement of the spherical bearings in their seats; lubrication of these bearings is recommended. The authors, in an attempt to use these fixtures in testing brittle materials at room temperature, employed carefully machined threads or split sockets. The spherical bearing and its seat were polished and various lubricants investigated. The most effective arrangement was to provide a rubber washer between the bearing and its seat. However, in all cases friction in the bearing was sufficient to prevent satisfactory alignment.

The ASTM, in Methods E 8 – 36,[6] recognized the limitations of the loading devices shown in Fig. 1 and recommended for brittle specimens a fixture which transmitted the load to the specimen through a ball. Such an arrangement provides much lower friction than is associated with the spherical seats in Fig. 1. The device, as shown in Methods E 8 – 36, requires the use of loading rods threaded into the fixture. No specifications are given, however, regarding tolerances between mating parts which could influence the alignment obtained with the final assembly. Regarding this type of fixture, Sachs (6) has emphasized that damage to the ball seat can greatly increase the eccentricity.

In an attempt to reduce eccentricity in a commercial creep testing machine, the authors inserted universal joints between the specimen loading rods and creep machine heads. These joints were bored to receive the threaded loading rods. All threads outside the hot zone were carefully machined to reduce misalignment in mating parts to a minimum. This procedure reduced the maximum eccentricity[7] by approximately a factor of two. Nevertheless, with this improvement, the eccentricity at 400-lb load on an 0.25-in. diameter bar was still high (approximately 33 per cent). This value would be lower if it were possible to use close fitting threads in the hot zone of the furnace. The authors' experience indicates that generally a class No. 2 thread represents the closest fit that can be disassembled at the conclusion of a test even when a nonseizing compound is used.

Description of Axial Loading Creep Machine

The machine developed by the National Advisory Committee for Aeronautics is essentially similar to standard commercial units with the exception of: (*1*) special constructional features of the frame and lever, (*2*) design of the temperature-control circuit, and (*3*) provisions for axial loading.

Frame and Lever

An over-all view of the machine is shown in Fig. 2. It will be noted that the frame consists of three tubular posts and three plate cross members. This design has several advantages:

1. It combines maximum ridigity with minimum weight.
2. The three plates may be gang machined to receive the posts, and all other holes in the plates can then be located with respect to these gang-machined holes. This design permits accurate location of the lever and therefore of the upper loading yoke with respect to the lower loading yoke. The accurate location of the lever with respect to the attachment point of the lower loading fixture assists in reducing the misalignment which may be contributed by the basic machine.
3. The plate cross members and the posts are self-jigging for assembly. Therefore accurate positioning of these parts during welding is assured.
4. The areas of the plate cross members affected by welding are not extensive; consequently warping of the plates is held to a minimum.

The lever construction is simple and light in weight. Two ½-in. thick 24S-T aluminum plates comprise the body of a 20 : 1 lever and enclose the knife edges. The knife edge supporting the weight pan is movable to permit adjustment of the lever ratio on assembly. This feature allows considerable tolerance in the location of the knife-edge holes.

It will be noted that an adjustable counterweight is provided to permit

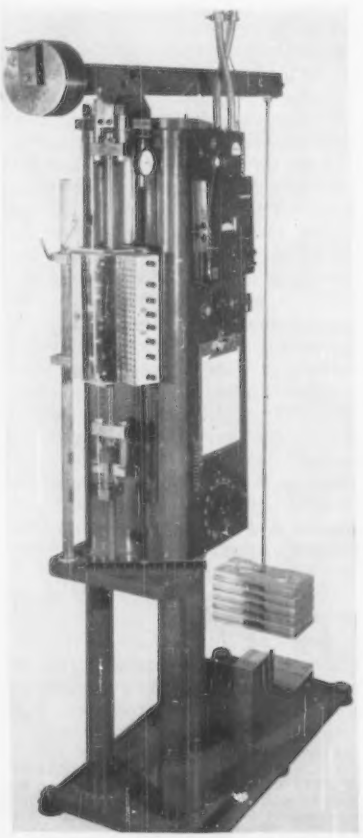


Fig. 2.—Axial Loading Creep Machine.

[6] Methods of Tension Testing of Metallic Materials (E 8–36), 1936 Book of ASTM Standards, Part I, p. 833.

[7] As will be discussed later, the eccentricity measured at a given load will vary with the relative positioning of the various loading assembly components, and the maximum value is that which must be considered.

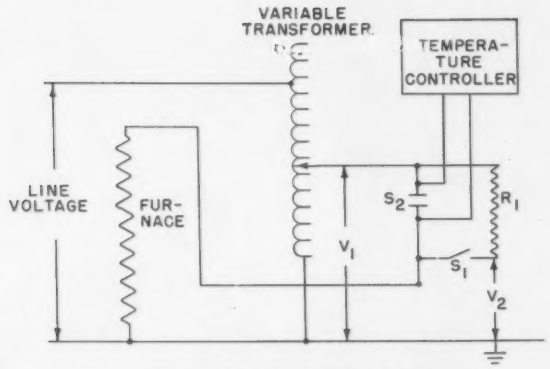


Fig. 3.—Temperature-Control Circuit Diagram.

balancing the tare associated with various loading fixtures.

Temperature-Control Circuit

A diagram of the temperature-control circuit is shown in Fig. 3. The variable transformer is manually set to provide a voltage, V_1, higher than that required to maintain the test temperature. A resistance, R_1, in series with the furnace, is switched in or out of the circuit by a temperature controller which senses the furnace temperature at a location near the windings. When the resistance is in the circuit, the voltage is reduced to a value V_2 which is less than that necessary to maintain the desired temperature. A toggle switch, S_1, is provided between R_1 and the relay S_2. When this switch is open, conventional on-off control is provided which permits the use of high power inputs for rapid initial heating. On reaching temperature, S_1 is manually closed and the variable transformer setting reduced to V_1.

Experience has shown that the solid contact type relays normally provided in such circuits are unsatisfactory, due to burning and sticking of the contacts. Therefore 25-amp plunger-type mercury relays have been used and have been found to provide satisfactory operation for a period of over 2 yr. In order to insure that temperature control could be maintained with ±25 per cent variation in the line voltage, R_1 was selected to have a value of approximately 50 per cent of the furnace resistance.

Axial Loading Fixture

The principle of the axial loading fixture lies in the fact that the load is applied through two balls accurately positioned in line with the axes of the loading rods. The specimen is attached to the loading rods by means of a precision fastening device. The magnitude of the eccentricity will depend on the magnitude of the tolerances permitted in machining the fixture and specimen.[3] Thus, the alignment is built into the fixture and specimen assembly. Any factors tending to produce eccentricity external to the assembly are compensated for by low friction loading through balls.

The general arrangement of the fixture is shown in Fig. 4. The loading balls are retained in recessed seats in the precision yokes, an arrangement that prevents damage to the seats when the specimen breaks and insures that the balls do not shift their position relative to the loading-rod holes. Load is applied to the ball by means of a yoke containing a pressed ball seat. This yoke is attached to the machine head by means of a threaded stud. In use, the ball seat is lubricated with molybdenum disulfide to assure low friction.

High-temperature alloy buttonhead loading rods are fastened in the precision loading yokes by means of surface ground split collars. The buttonhead specimen is attached to these rods and loaded by precision-machined split adapters. This construction, Fig. 5, permits the use of closer tolerances in the hot zone than are possible with threads.

Threaded specimens may also be used with this fixture. For this purpose, loading rods with a buttonhead on one end and female thread on the other end may be substituted for those shown in Fig. 4. When threaded specimens are used in the fixture, some sacrifice must be accepted in the accuracy of alignment. However, lower eccentricities are obtained than can be realized with any other tension loading arrangement for threaded specimens known to the authors.

Performance of Equipment

Tests were made on the loading mechanism and temperature control circuits to: (*a*) calibrate the lever, (*b*) determine the influence of line voltage variation on the specimen temperature, and (*c*) determine the eccentricity of loading for both threaded and buttonhead specimens.

Calibration of the Lever

The lever ratio was set to 20 : 1 by adjusting the position of the weight pan knife edge pin so that the lever was in balance with no load and so that it

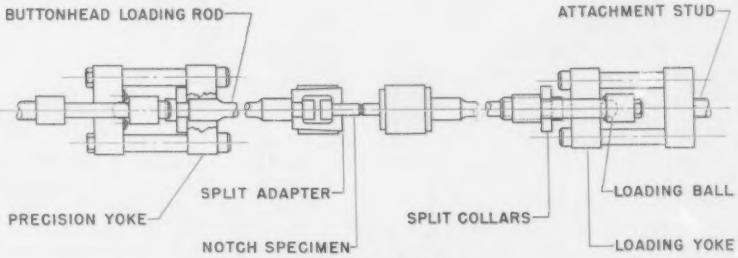


Fig. 4.—Axial Loading Fixture.

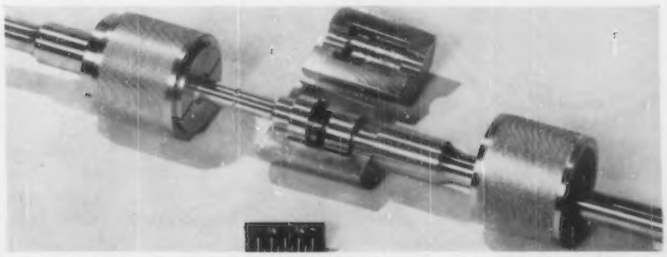


Fig. 5.—Split Adapters for Attaching Buttonhead Specimens to Buttonhead Loading Rods.

[3] The various precision components of the axial loading fixture requiring careful machining have been made with tolerances not exceeding ±0.0005 in.

Fig. 6.—Strain Gage Setup for Determination of Eccentricity.

remained in balance with a dead weight load on the specimen loading yoke 20 times the load applied to the weight pan.

In some cases, it has been the practice to calibrate the lever over a range of loads with a proving ring. It should be realized, however, that geometrical conditions fix the lever ratio, and these conditions are not altered by the magnitude of the load.

In actual use the lever usually is not horizontal at the start of a test and may move appreciably before the specimen fractures. Such angular displacement exerts an entirely negligible effect on the actual load applied to the specimen (see Appendix I).

Effect of Voltage Variation

Variations in line voltage were simulated by changing the setting of the variable transformer and noting the corresponding specimen temperature change for control settings of 1000 and 1500 F. In all cases, temperature records were made for a sufficient length of time to insure that the specimen temperature had come to equilibrium for a particular variable transformer setting. Voltages were measured directly across the furnace windings.

The results of these tests indicate that at 1000 or 1500 F a line voltage change of ±25 per cent would produce a specimen temperature variation of ±3 F. A line voltage change of ±18 per cent would produce a temperature change of ±2 F.

It should be noted that changes in room temperature, in addition to voltage variation, can influence the specimen temperature. The authors' experience indicates that room-temperature variations reflect themselves primarily in the voltage output of the working cell used in the temperature-control bridge circuit. Variations in this voltage will affect the specimen temperature unless the instrument is frequently standardized. The problem should not be present if a self-standardizing controller is employed. An equally satisfactory solution is the use of an electronic constant circuit supply[9] in place of a wet or dry battery. These units provide a constant output current through a constant resistive load, thus producing a stable reference voltage which is maintained over a range of ambient temperatures and line voltage variations. When constant current supplies are employed, it is the experience of the authors that specimen temperature variations exceeding ±3 F can be attributed to specific errors in the test procedure and not to voltage or to temperature variations in a room provided only with normal building temperature control.

[9] Manufactured by the Weston Electric Instrument Corp.

Eccentricity Measurements

Eccentricity measurements were made using a buttonhead and a threaded specimen in the axial loading creep machine and using the same threaded specimen in a commercial machine. This latter machine possessed as standard equipment a spherical seat ball thrust bearing at the fastening point of the lower loading rod. This arrangement is intended to aid in lowering the eccentricity.

The buttonhead and threaded specimens were made of tool steel and had an 0.25-in. diameter with 1- and 2-in. gage lengths, respectively. Both were carefully ground to insure that all surfaces which could influence the alignment—including the threads—were machined with tolerances not exceeding ±0.0005 in. It is felt that the gage lengths and specimen diameter selected are somewhat smaller than would be normally encountered in service applications. For a given value of initial eccentricity, an increase in length would tend to reduce the bending stresses at high loads. Furthermore as can be seen from Eq 9, Appendix II, an increase in diameter would reduce the bending stress for a given value of eccentricity at any load. Each specimen was provided with four single-wire Karma resistance gages of a length approximately equal to the gage length and spaced circumferentially 90 deg apart. The use of single-wire gages insures that the strain measured represents as closely as possible that of a single surface fiber.

Strain data were taken using a Baldwin SR-4 strain indicator reading directly in microinches per inch. A typical test setup is shown in Fig. 6, in this case with the threaded specimen. In general, strain readings were taken after each 20-lb increment of load was added to the weight pan. The measured value of eccentricity in a given loading system is subject to chance factors associated with relative positioning of the various components of this system. Therefore, in the following tests, the positioning of the components was systematically varied to insure that the maximum value of the eccentricity at a given load was obtained. The data were reduced to per cent bending and to inches of eccentricity by methods outlined in Appendix II, assuming constant moment bending and uniformity of the longitudinal strain distribution. This assumption is probably not strictly correct. However, the values reported are direct indications of the relative ability of the investigated loading devices to provide low eccentricity.

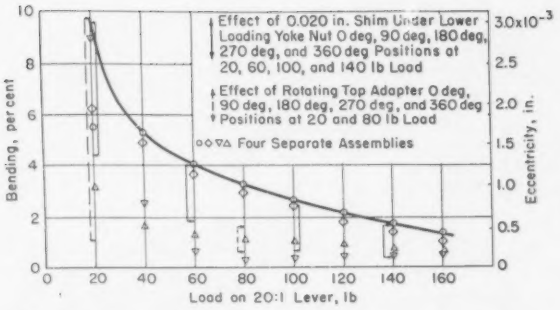

Effect of 0.020 in. Shim Under Lower Loading Yoke Nut 0 deg, 90 deg, 180 deg, 270 deg, and 360 deg Positions at 20, 60, 100, and 140 lb Load
Effect of Rotating Top Adapter 0 deg, 90 deg, 180 deg, 270 deg, and 360 deg Positions at 20 and 80 lb Load
Four Separate Assemblies
Bending, per cent
Eccentricity, in.
Load on 20:1 Lever, lb

Fig. 7.—Per Cent Bending and Eccentricity as a Function of Load for Axial Loading Creep Machine Using Buttonhead Adapters and 0.25-in. Diameter, 1-in. Gage Length Specimen.

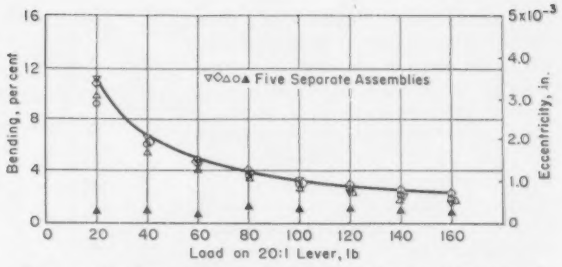


Fig. 8.—Per Cent Bending and Eccentricity as a Function of Load for Axial Loading Creep Machine Using Threaded Loading Rods and 0.25-in. Diameter, 2-in. Gage Length Specimen.

Results are shown in Figs. 7 to 9 in which per cent bending (based on the ratio between the maximum bending stress to the average stress) and the corresponding eccentricity are plotted as a function of load applied to the 20 : 1 lever. In all cases these values decrease continuously with increasing load. This is explained by increasing elastic deflections in the assembly as the load is increased, which tend to bring the specimen into alignment.

Four separate assemblies were made using the buttonhead specimen. Each assembly was systematically varied from the previous one, by changing the relative orientation of the loading rods, split adapters, and split collars. Referring to Fig. 7, the various assemblies produced different values of eccentricity at each load. In addition, the independent effect of rotating one split adapter was investigated at a load of 20 lb, where the measured eccentricities are high. The vertical dotted line at this load indicates the spread of values obtained.

The lower loading yoke is attached to the machine by means of a $\frac{3}{4}$-10 NC stud passing through a clearance hole in the lower head. An 0.020-in. shim was placed between the nut on this stud and its bearing surface on the lower head of the machine. This was done to determine the effectiveness of the axial loading fixture in compensating for eccentricities that might be introduced if for any reason there were gross misalignments of the load applied to the fixture. The solid vertical lines in Fig. 7 indicate the spread of values obtained by varying the position of this shim.

The various procedures used yield at a given load very nearly the same maximum values of eccentricity. This fact indicates that the conditions yielding highest eccentricity have been established for this loading system. These maximum values are indicated as a function of load by the curve in Fig. 7.

The results obtained using the axial loading fixture and the threaded specimen are shown in Fig. 8. In this case five separate assemblies were made in which the threaded loading rods were systematically rotated in respect to the specimen and to one another. Again a curve has been drawn to indicate the maximum eccentricity obtained at a given load.

The results obtained using the threaded specimen in a commercial machine are shown in Fig. 9. Again separate assemblies were made and the loading rods rotated as described above.

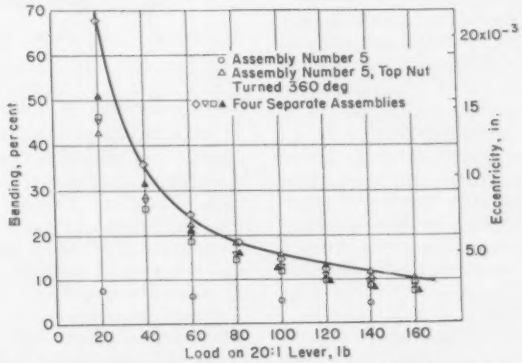

Assembly Number 5
Assembly Number 5, Top Nut Turned 360 deg
Four Separate Assemblies
Bending, per cent
Eccentricity, in.
Load on 20:1 Lever, lb

Fig. 9.—Per Cent Bending and Eccentricity as a Function of Load for a Commercial Creep Machine Using Threaded Adapters and 0.25-in. Diameter, 2-in. Gage Length Specimen.

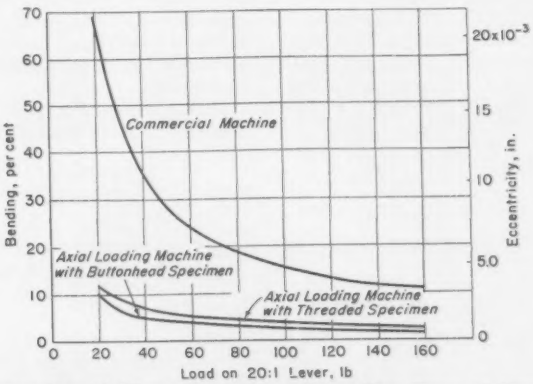

Commercial Machine
Axial Loading Machine with Buttonhead Specimen
Axial Loading Machine with Threaded Specimen
Bending, per cent
Eccentricity, in.
Load on 20:1 Lever, lb

Fig. 10.—Comparison of Alignment Obtained Using Two Types of Creep Machines, Values represent the maximum obtainable.

It will be noted that one assembly (No. 5) gave values of eccentricity considerably lower than the others. Another series of measurements was made on this same assembly with the top loading rod fastening nut turned 360 deg. As can be seen from Fig. 9, the influence of this minor modification was to increase the eccentricity greatly.

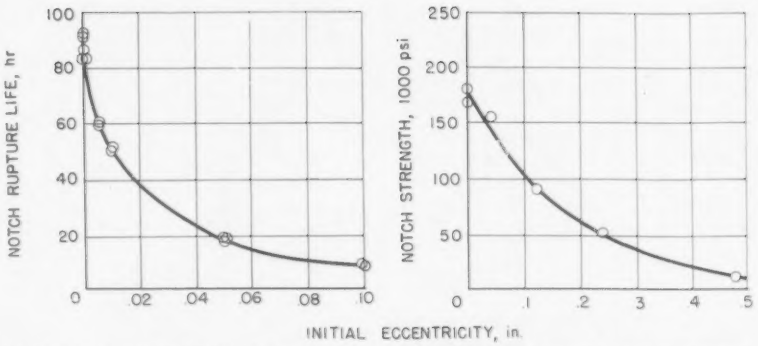
The curves from Figs. 7 to 9 indicating the maximum values of eccentricity as a function of load are compared in Fig. 10. This comparison must be made on

the basis of the maximum values since there is a possibility of these occurring when the fixtures are used in normal testing. It is evident that the axial loading fixture yields much lower values than the commercial machine and that the best results are obtained using buttonhead specimens. Suprisingly low values of eccentricity were obtained using the threaded specimen in the axial loading fixture. This, however, represents a nearly ideal case for threaded joints; the values would be higher if the specimen thread clearance were increased to a value suitable for elevated-temperature testing. In addition, threads in the hot zone are subject to progressive deterioration with use, which increases the clearance and consequently the eccentricity. Furthermore, removal of threaded specimens from their loading rods at the conclusion of a test may be a difficult procedure which can result in damage to the loading rod threads.

The situation is considerably better when using buttonhead specimens. Progressive deterioration does not result in increased clearances at the specimen fastening because split adapters are used at this point. In addition, split adapters permit easy disassembly at the conclusion of a test.

In this regard, it should be pointed out that in the above described tests new threaded loading rods were used, whereas the buttonhead loading rods and split adapters had seen several thousand hours of service at elevated temperature.

It should be mentioned that the values of eccentricity and per cent bending obtained will vary with the geometry of the specimen and that the values reported are characteristic of the test setup employed in this investigation.



(*a*) 1000 F, 60,000 psi notch rupture tests, Cr, Mo, V steel.

(*b*) Notched tension tests at room temperature, SAE 3140, 270,000 psi, strength level (1).

Fig. 11.—Rupture Life and Strength Plotted Against Initial Eccentricity.

Effect of Eccentricity in Rupture Tests

There is no published information relating to the influence of eccentricity on the rupture life of either notch or smooth bars. Therefore, a series of tests were undertaken on a Cr-Mo-V steel to determine the effect of eccentricity on the notch rupture life at 60,000 psi and 1000-F. Buttonhead specimens were tested in the previously described creep machine. The longitudinal axis of the notch section was displaced from that of the heads by an amount defined as the initial eccentricity. The notch had a 60-deg flank angle, removed 50 per cent of the cross-sectional area, and had a root radius of 0.001 in. The rupture life is plotted in Fig. 11(*a*) against the initial eccentricity.

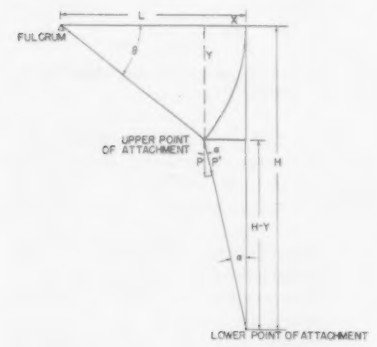
Similar effects, Fig. 11(*b*), have been observed in notch tensile tests at room temperature by Sachs and Lubahn (1). From these representations the following conclusions may be drawn for notch brittle materials: (1) the strength in rupture tests or tension tests is reduced by an increase in the eccentricity, (2) the scatter normally encountered in rupture lives using conventional creep machines can be due in part to the initial eccentricity which varies from test to test. (3) the small scatter observed in Fig. 11(*a*) for the rupture life at "zero" eccentricity indicates that the testing equipment used introduces very little eccentricity.

Acknowledgment:

The authors wish to express their appreciation to O. T. Hickey and S. P. Barnosky for their assistance with the tests. Thanks are also due to D. P. Newman for his helpful advice and criticism.

APPENDIX I

CALCULATIONS SHOWING THE SPECIMEN LOAD ERROR DUE TO DISPLACMENT OF THE CREEP MACHINE LEVER FROM HORIZONTAL



12.—Diagram Showing the Effect of Lever Movement on the Actual Load Applied to the Specimen.

A load on the weight pan will produce a tensile force, P, on the specimen when the lever is horizontal. Considering the geometrical relations shown in Fig. 12, this force is reduced to P' by an angular deflection, θ, of the lever. It is evident that:

$$P' = P \cos \alpha \quad \ldots\ldots\ldots (1)$$

The angle, α, for a given length, L, will be a function of the distance, H, between the upper and lower points of attachment and also of the angular deflection, θ, of the lever. Thus:

$$\tan \alpha = \frac{x}{H - y} = \frac{L - L \cos \theta}{H - L \sin \theta} \quad \ldots (2)$$

where x and y are the horizontal and vertical displacements of the upper point of attachment associated with the angular deflection θ. Since $L \sin \theta \ll H$ it may be neglected, giving the following expression:

$$\tan \alpha = \frac{L - L \cos \theta}{H}$$

Considering the machine described in this report, $H = 42$ in. (an average value which differs slightly depending on the specimen length), $L = 1.75$ in., and θ is a maximum of 15 deg as determined by the angle of the knife edge "V" blocks. The angle, α, is therefore approximately 5 min at maximum lever deflection. Referring to Eq 1, it is seen that this value produces an entirely negligible difference between the applied load and the actual load. The same result would be expected for any normal type of creep machine.

APPENDIX II

CALCULATIONS FOR BENDING OF ECCENTRICALLY LOADED SPECIMEN

These calculations develop an expression for the per cent bending from longitudinal strain measurements taken at several circumferential positions on an eccentrically loaded cylindrical tension specimen assuming constant moment bending. Referring to Fig. 13, it is seen that the maximum bending stress, σ_m, and the angular position, α, of the bending plane in relation to one gage position could be determined from two gages placed 90 deg apart. For example, consider the gage positions Nos. 1 and 4 in Fig. 13; the stresses σ_1 and σ_4 at these locations and σ_m are given by the following equations:

$$\left.\begin{aligned} \sigma_1 &= \sigma_0 + \frac{Mb}{I} = \sigma_0 + \frac{Ma \sin \alpha}{I} \\ \sigma_4 &= \sigma_0 + \frac{Me}{I} = \sigma_0 + \frac{Ma \cos \alpha}{I} \\ \sigma_m &= \sigma_0 + \frac{Ma}{I} \end{aligned}\right\} \quad \ldots(1)$$

where:

M = the bending moment,
b and e = perpendicular distances from the neutral axis to gage positions Nos. 1 and 4, respectively,
a = the radius of the specimen, and
I = the moment of inertia.

However, this method requires that the average stress, σ_0, be computed from the tensile load divided by the cross-sectional area and provides no indication of the reliability of the gage readings.

The authors have preferred to use four gages located 90 deg apart as shown in Fig. 13. The stresses, σ_1, σ_2, σ_3, and σ_4, at these locations can be averaged and should equal the stress computed on the basis of the tensile load divided by the cross-sectional area. In addition, because of the symmetry of the elastic stress distribution, gages at opposite ends of a diameter serve as a check on one another, inasmuch as they should yield stresses differing from the average stress by the same amount. These differences are:

$$\left.\begin{aligned} \Delta\sigma_1 &= (\sigma_1 - \sigma_0) = \Delta\sigma_3 = -(\sigma_3 - \sigma_0) \\ \Delta\sigma_4 &= (\sigma_4 - \sigma_0) = \Delta\sigma_2 = -(\sigma_2 - \sigma_0) \end{aligned}\right\} \quad \ldots(2)$$

By averaging the $\Delta\sigma$'s in Eqs 2, the problem may be treated as one of two gages located 90 deg apart. Thus:

$$\left.\begin{aligned} \Delta\sigma_{1,3} &= \frac{\Delta\sigma_1 + \Delta\sigma_3}{2} \\ \Delta\sigma_{4,2} &= \frac{\Delta\sigma_2 + \Delta\sigma_4}{2} \end{aligned}\right\} \quad \ldots\ldots(3)$$

Equations 1 may be rewritten in terms of $\Delta\sigma_{1,3}$ and $\Delta\sigma_{4,2}$ as follows:

$$\left.\begin{aligned} \Delta\sigma_{1,3} &= MK \sin \alpha \\ \Delta\sigma_{4,2} &= MK \cos \alpha \\ \Delta\sigma_m &= MK \end{aligned}\right\} \quad \ldots\ldots(4)$$

where $K = I/a$. Solving Eqs 4 for $(MK)^2$:

$$(MK)^2 = (\Delta\sigma_{4,2})^2 + (\Delta\sigma_{1,3})^2$$

$$(MK)^2 = (\Delta\sigma_m)^2$$

The following expression is then obtained for $\Delta\sigma_m$:

$$\Delta\sigma_m = \sqrt{(\Delta\sigma_{4,2})^2 + (\Delta\sigma_{1,3})^2} \quad \ldots\ldots(5)$$

The per cent bending is defined as:

$$B = \frac{\Delta\sigma_m}{\sigma_0} \times 100 \quad \ldots\ldots(6)$$

Since the gages read directly in microinches per inch, the gage readings g_1, g_2, g_3, and g_4 can be substituted directly into Eq 5 to yield the following expression for the per cent bending:

$$B = \left(\frac{\Delta\sigma_m}{\sigma_0}\right) 100 = \left(\frac{\sqrt{(\Delta g_{1,3})^2 + (\Delta g_{4,2})^2}}{g_0}\right) 100 \quad \ldots(7)$$

where from Eqs 2 and 3:

$$\Delta g_{1,3} = \frac{(g_1 - g_0) - (g_3 - g_0)}{2}$$

$$\Delta g_{4,2} = \frac{(g_4 - g_0) - (g_2 - g_0)}{2}$$

$$g_0 = \frac{g_1 + g_2 + g_3 + g_4}{4}$$

The eccentricity associated with a given percentage of bending will depend on the specimen diameter. From Eqs 1 consider the expression for the maximum stress, σ_m, rewritten as follows:

$$\sigma_m - \sigma_0 = \frac{Ma}{I} \quad \ldots\ldots(8)$$

Dividing by σ_0 and multiplying by 100, an equation for the per cent bending is obtained:

$$B = \left(\frac{\sigma_m - \sigma_0}{\sigma_0}\right) 100 = \left(\frac{Ma}{\sigma_0 I}\right) 100$$

The bending moment, M, is produced by the tensile load, P, acting at an eccentricity, ϵ. Thus:

$$B = \frac{400 P \epsilon}{\sigma_0 \pi a^3} \quad \ldots\ldots(9)$$

where $I = \pi a^4/4$. Considering the average stress $\sigma_0 = P/\pi a^2$, Eq 9 may be solved for the eccentricity as follows:

$$\epsilon = \frac{Ba}{400}$$

where $2a$ is the diameter of the specimen.

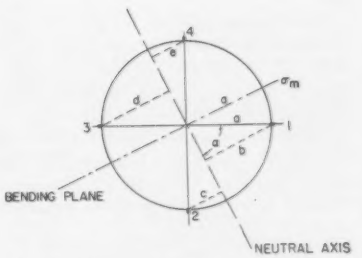


Fig. 13.—Diagram Showing Strain Gage Positions on a Cylindrical Specimen and Their Relation to the Neutral Axis and Bending Plane.

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(2) Symposium on Strength and Ductility of Metals at Elevated Temperatures with Particular Reference to Effects of Notches and Metallurgical Changes, Am. Soc. Testing Mats. (1952). (Issued as separate publication *ASTM STP No. 128*.)

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(4) L. A. Shepard and J. E. Dorn, "Equipment for Testing the Creep Properties of Metals Under Intermittent Stressing and Heating Conditions," Wright Air Development Center *Technical Report No. 52-101*, Part I, July, 1952.

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(Please turn page for Discussion)

DISCUSSION

MR. N. L. MOCHEL.[1]—The ASTM-ASME Joint Committee on Effect of Temperature on the Properties of Metals has a panel studying methods of testing, and it is very pertinent that this paper should appear at this time; our panel should give very careful consideration to the matter of eccentric loading. Failures of both serrated and threaded members in service, even rather large sizes, have been the result of eccentric loading.

The values that were presented in Fig. 11 are quite pertinent in this matter. Turbine builders go to great lengths to make sure that the threads on threaded members are very accurately formed, even tapered threads, to stretch out the loadings and make them uniform, and to make sure that holes and tapped holes are accurately machined to the base member. This is an extremely important matter, because if threads are not axially loaded, failures will occur that are quite disturbing, even in large size.

A MEMBER.—Other methods in connection with testing are quite interesting. Shackling, if it may be called that, is quite a forward step. In some of our work, we have tried to improve axial loading by discarding the lever entirely and by simply using a dead weight load creep testing machine. Using lead weights it is possible to get a very considerable load and that load can be applied rather uniformly. Possibly by the use of the dead weight load machine and new shackles, one can get good accurate axial loadings.

MR. M. J. MANJOINE.[2]—The authors should be commended for their efforts to improve the art of creep testing. In testing notched specimens it is very important to reduce the amount of eccentricity. The use of buttonhead specimens aids in this reduction and has the additional advantage in that they can be machined at a lower cost than threaded specimens.

In testing smooth bars in tension, the degree of axiality is not so important if the material being tested has a ductility of over 5 per cent. The reason is that the specimen will always deform in such a way as to reduce the amount of eccentricity. Thus, after only a few tenths of a per cent strain, the axis of the gage length of the specimen will practically coincide with that of the load. There will be some error, however, in these initial strain readings while the specimen is reducing the eccentricity.

MR. JOHN A. VAN ECHO.[3]—I wonder if the authors would define what they mean by per cent bending.

MR. BROWN (*authors' closure*).—The authors wish to thank Messrs. Mochel, Manjoine, and Van Echo for their interesting and complimentary remarks. We are very pleased that there is an appreciation for the desirability of axial loading on the part of those who have been leaders in the field of materials testing. It is our hope that the ASTM will give further attention to the problem of alignment in both tension and creep tests. Specifically it would seem that the recommendations set forth in Methods E 8, E 21, and E 22 regarding the alignment could be made both more meaningful and rigorous.

The use of dead weight tension loading devices has obvious advantages when the loads are relatively low. Elimination of the lever system may reduce the difficulties in achieving axial loading. However, careful design of the grips and specimen is still necessary to reduce bending moments to a minimum.

Mr. Manjoine has mentioned the lower cost of buttonhead as compared to threaded specimens. We have found this to be true when class 3 fit threads are specified. However, such close fitting threads cannot be used successfully at elevated temperatures for reasons described in the body of the paper. Normally we pay the same for class 2 fit threads as we do for buttonheads.

The authors recognize the fact that sufficient plastic flow will eliminate the bending stresses. However, the amount necessary to do this will depend on the specimen geometry, and also on the manner in which the eccentricity is introduced. We have not systematically investigated the influence of eccentricity on the rupture strength of smooth bars, but see no reason why the rupture lives of relatively brittle materials would not be reduced. Consequently, we have also made efforts to reduce the eccentricity in the testing of smooth bars.

Mr. Van Echo has asked that "per cent bending" be defined. This term is defined in Appendix II of the paper and equations for its calculation are developed.

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[2] Research Engineer, Westinghouse Electric Corp., East Pittsburgh, Pa.
[3] Research Engineer, Battelle Memorial Inst., Columbus, Ohio.

Help Wanted

Ordnance engineering cuts across many fields of science and technology, and information for design work is drawn from many diverse fields of knowledge. If there is some chance that your subject field might be of interest in ordnance work, and if you have either formal or informal collections of terminologies, glossaries, specialized dictionaries, or even references to them—please contact:

Allen Kent, Associate Director
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Several months ago, the Army Ordnance Corps initiated the preparation of a comprehensive Ordnance Engineering Design Handbook to summarize fundamental principles and basic design data. The handbook is being written to provide needed information to army ordnance and arsenal personnel and to the engineering staffs of contractors having ordnance design responsibilities. It is planned that the handbook will consist of approximately 180 sections of about 100 pages each. Completion of the first edition of the handbook is expected to require about five years. The format is being worked out so as to facilitate revision of individual sections as may be required by future developments.

Final impetus to prepare the Ordnance Engineering Design Handbook developed during the Korean War when it became evident that availability of a central reference of ordnance design information would have materially speeded up the design, development, and production of new military weapons. In a future conflict, need for such available publications may be even more acute.

It is a matter of considerable importance that uncertainties as to the meaning of terminology and nomenclature do not impede ordnance design and development. Cooperation in avoiding confusion as to meanings of terms should prove helpful not only to designers and users of ordnance, but also to you.

Because of the wide field involved, some 30 to 40 different engineering societies, Government bureaus, trade associations, institutes, and the like now have one or more representatives on the sectional committee plus a few "members at large" to represent general interests. Code activities are subdivided according to the scope of the several sections and chapters listed in the Table of Contents. General direction of code activities rests with the sectional committee officers and an executive committee whose membership consists principally of sectional committee officers and section chairmen. There also is a subcommittee on Coordination (editing and interpretations) and another on Liaison with Other Codes and Standards.

The reorganized Sectional Committee B31 made an extensive review of the 1942 code which resulted in: (1) a general revision and extension of requirements to agree with present-day practice; (2) the revision of references to existing dimensional standards and material specifications and the addition of references to new ones; and (3) the clarification of ambiguous or conflicting requirements. A revision was prepared which was finally approved as American Standard in February, 1951, with the designation B31.1—1951.

Following the publication of the 1951 code, the committee that had been working jointly with the ASME Boiler Code Committee and ASA Sectional Committees B16 and B36 recommended a revised basis for establishing allowable stresses for certain materials common to the several codes and standards. Sectional Committee B31 approved this new basis for establishing allowable stresses, and in order to make the revisions available to code users, issued Supplement 1 to the Code B31.1—1953 which had received ASA approval April 30, 1953.

At its meeting November 29, 1951, Sectional Committee B31 authorized separating Section 2 on Gas and Air Piping Systems into two sections—Section 2 on Gas and Air Piping for Industrial Installations, and Section 8 on Gas Transmission and Distribution Piping Systems. The latter section was to incorporate the applicable parts of Section 6 Fabrication Details, and Section 7 Materials—Their Specifications and Identification. The purpose was to provide an integrated document for Gas Transmission and Distribution Piping which would not require cross-referencing to other sections of the code. Upon completion it was approved by the ASA September 29, 1952, with the designation B31.1-8—1952. Section 2 was rewritten in the light of its new scope and became a part of this 1955 revision.

Developments indicated the need for further work on Section 8, so the committee was reorganized and started work on a revision. This resulted in the 1955 edition of Section 8 which was approved by ASA on March 11, 1955, and is printed as a complete and self-contained document, B31.1.8—1955.

The remaining sections of the code have been printed in a single document and all sections have been revised to bring them up to date with present practices, Section 6 on Fabrication Details having the most extensive revision. The ASA approved this 1955 code on August 17, 1955. Future plans of the committee contemplate sections on Chemical Industry Process Piping and Oil Transportation Piping.

Recommended Practices for Interruption of Heat-Treatment Cycles for Low-Chromium-Molybdenum Steel Piping Materials

American Welding Society, 33 W. 39th St., New York 18, N. Y.; 50 cents.

THIS publication deals with the interruption of heat cycles in the welding of low-chromium-molybdenum steel piping materials. The recommendations apply to materials containing up to, and including, 5 per cent chromium and 1 per cent molybdenum.

Present practices in the various industries are given regarding the interruption of preheat and welding. The five factors to be considered in determination of the heating cycle are outlined in detail. Finally recommendations based on industry experience are made for specific materials.

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Tensile Crack Exposure Tests for Reinforced Concrete Beams

Waterways Experiment Station, Corps of Engineers, U. S. Army, Vicksburg, Miss.; 75 cents

THIS report describes tests conducted for the Office, Chief of Engineers, to determine the relationship, for different types of reinforcing steel, between the degree of tensile stress in the steel and the resistance of reinforced-concrete to severe natural weathering.

OTHER SOCIETIES' EVENTS

February 1–3—**Case Institute Studies in Operations Research,** Case Institute of Technology, 10900 Euclid Ave., Cleveland 6, Ohio.

February 7–9—**Society of Plastics Industry,** Annual Conference, Reinforced Plastics Div., Hotel Chalfonte-Haddon Hall, Atlantic City, N. J.

February 13–16—**National Sand and Gravel Assn.,** 40th Annual Convention and Biennial Show, Conrad Hilton Hotel and Chicago Coliseum, Chicago, Ill.

February 13–16—**National Ready Mixed Concrete Assn.,** 26th Annual Convention and Biennial Show, Conrad Hilton Hotel and Chicago Coliseum, Chicago, Ill.

February 20–22—**National Crushed Stone Assn.,** 39th Annual Convention and Exposition, Conrad Hilton Hotel, Chicago, Ill.

February 20–23—**American Concrete Institute,** Annual Meeting, Philadelphia, Pa., Bellevue-Stratford Hotel.

February 20–23—**TAPPI,** 41st Annual Meeting, Commodore Hotel, New York, N. Y.

February 24—**Malleable Founders Society** Western Section Meeting, Drake Hotel, Chicago, Ill.

February 26–29—**American Institute of Chemical Engineers,** Los Angeles, Calif.

February 27–March 2—**Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy,** Exposition of Modern Laboratory Equipment, Wm. Penn Hotel, Pittsburgh, Pa.

March 1–2—**Forest Products Research Society,** Royal York Hotel, Toronto, Ontario, Canada.

March 8–9—**Society of Plastics Industry,** 14th Annual SPI Canadian Conference, Sheraton-Brock Hotel, Niagara Falls, Ontario, Canada.

March 12–16—**National Association of Corrosion Engineers,** Show, Hotel Statler, New York City.

March 15–16—**Steel Founders Society,** Annual Meeting, Drake Hotel, Chicago, Ill.

March 18–21—**American Society of Mechanical Engineers,** Spring Meeting, Multonomah Hotel, Portland, Ore.

March 19–23—**American Society of Tool Engineers,** 24th Annual Convention, International Amphitheatre, Chicago, Ill.

March 21–24—**National Institute of Radio Engineers,** Convention and Exhibit, Belmont Plaza, New York City.

March 27–April 2—**Society of Plastics Industry,** 13th Annual Pacific Coast Section Conf., St. Francis Hotel, San Francisco, Calif., and S. S. *Lurline* to Honolulu.

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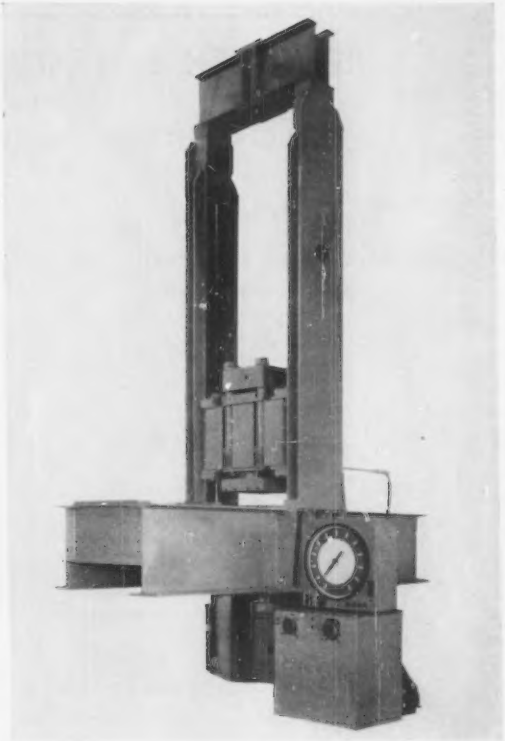

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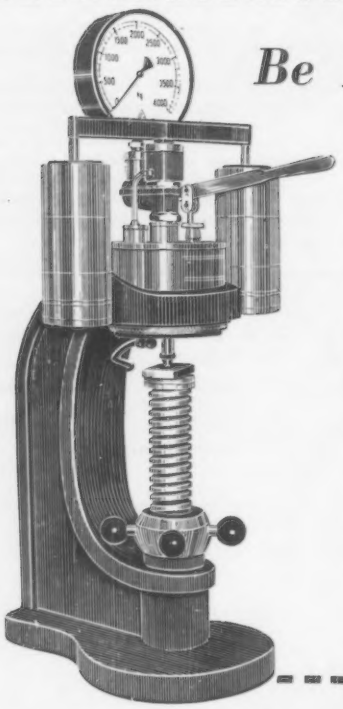

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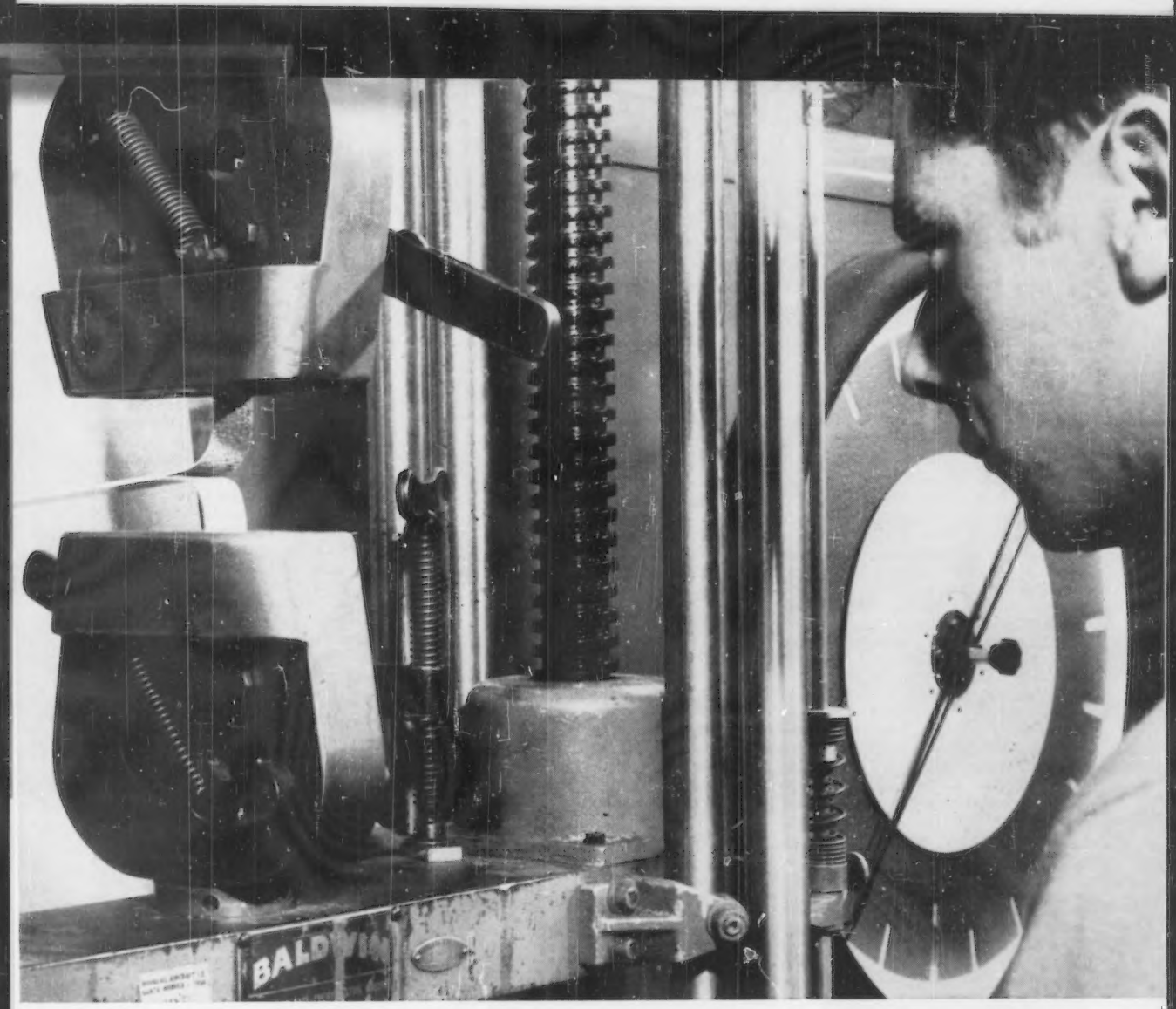

Douglas Aircraft's new tear and peel tests prove versatility of 5000-lb. Baldwin machine

Douglas Aircraft Company finds their versatile Baldwin gives accurate, flexible testing in two new tests devised by them. At their Santa Monica, California Materials Laboratory tear and peel tests on titanium sheet and metal bonding adhesives, respectively, are being run on this 5000-lb. universal machine.

The tear test is used to determine usable quality sheet before release to the factory. It also measures brittleness, formability and strength. The test is conducted on the Baldwin by applying tension loads to a specially-prepared specimen engaged in steel hooks. By pulling the ears of the specimen, tearing originates at a pre-set point produced by a notch. The load increases until reaching the force required to start the tear from the notch. Then the load drops off rapidly or slowly in relation to the brittleness or ductility of the material. The load is autographically recorded along with the strain during the test.

Their peel test operation measures tensile strength of metal bonded specimens. Test panels are gripped in the jaws of the Baldwin machine and are peeled apart at a jaw separation rate of two feet per minute, separating the bond at a rate of one foot per minute. An autographic record versus crosshead motion is obtained. The test includes measurement of average adhesive film thickness and type of failure.

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PERSONALS...

News items concerning the activities of our members will be welcomed for inclusion in this column

NOTE—These "Personals" are arranged in order of alphabetical sequence of the names. Frequently two or more members may be referred to in the same note, in which case the first one named is used as a key letter. It is believed that this arrangement will facilitate reference to the news about members.

The 1955–56 American Society for Metals Board of Trustees includes the following very active ASTM members: **A. O. Schaefer** (ASM President), Vice-President-Executive Assistant, The Midvale Co.; **D. S. Clark** (ASM Vice-President), Professor of Mechanical Engineering, California Institute of Technology; **C. H. Lorig** (ASM Treasurer), Technical Director, Battelle Memorial Institute; **W. H. Eisenman** (ASM Secretary); **George A. Roberts** (ASM Past-President), Vice-President, Technology, Vanadium Alloys Steel Co.; **Walter Crafts,** Associate Director of Research, Electro Metallurgical Division, Union Carbide & Carbon Co.; **Karl L. Fetters,** Assistant to Vice-President in Charge of Operations, Youngstown Sheet and Tube Co.; and **G. E. Shubrooks,** Manager of Research Laboratories, Hamilton Watch Co. ASM President Schaefer recently served a term on the ASTM Board of Directors, heading the Committee on Membership.

E. C. Bain, Vice President, Research and Technology, U. S. Steel Corp., Pittsburgh, Pa., has been invited to deliver the 8th Hatfield Memorial Lecture of the University of Sheffield, England.

ASTM Past-President **Herbert J. Ball** recently retired as Chairman of the Lowell Technological Institute Division of Engineering embracing the departments of Electronics Engineering, Leather Engineering, Paper Engineering, and Textile Engineering. He had served also as Head of the Department of Textile Engineering from 1919 until his retirement. His service on the LTI Staff dates from 1906. He has been requested by administrative officers of the Institute to continue to teach one of the advanced courses and take on two assignments importantly connected with the future of the Institute. He has the same office and can be contacted as heretofore. Professor Ball's friends and committee associates in ASTM will be pleased to learn that he expects to continue to attend meetings and maintain active interest in the work of the Society. Affiliated since 1929, he served two terms (1934–36, 1939–40) on the Board of Directors; was Vice-President, 1940–42; and President, 1942–43. He has served on Committee D-13 on Textile Materials since 1929; was Chairman from 1930 to 1950, and is now Honorary Chairman. He has been Chairman of the Administrative Committee on Ultimate Consumer Goods since its formation in 1945, and a member of the New England District Council since its organization in 1946.

Harry L. Beede has retired as Director of Research, The Okonite Co., Paterson, N. J. A member of the Society for a number of years, Mr. Beede has represented his company on Committee D-9 on Electrical Insulating Materials.

Jewell R. Benson, formerly with Rubarite, Inc., Chicago, is now engaged as a Consulting Bituminous Engineer, 1628 Glencoe St., Denver, Colo.

John W. Bizot has been appointed Chief Metallurgist, Kaiser Aluminum and Chemical Corp., Permanente, Calif., foil mill.

Hyman Bornstein, retired Director of Laboratories, Deere & Co., Moline, Ill., has been named temporary secretary of the American Foundry Society Alumni Group to fill the gap left by the death of R. E. Kennedy, AFS secretary emeritus, and secretary of the Alumni Group.

Kenneth R. Brown, Vice-President and Director of Research, Atlas Powder Co., Wilmington, Del., received the 1955 honor award of the American Chemical Society Division of Carbohydrate Chemistry. The award is presented annually for outstanding achievement in the field of carbohydrate chemistry. Mr. Brown was honored for pioneering work in the development of sorbitol and related carbohydrate products. The chemical was a test-tube curiosity when he began working on it.

Russell B. Caples was elected Vice-President in Charge of Metallurgical Operations, Anaconda Co. He succeeds Frederick Laist who retired after 51 years with the company. Mr. Caples is also President of the Anaconda Aluminum Co.

C. F. Cheng, formerly Metallurgical Engineer, The International Nickel Co.,

(*Continued on page 70*)

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(*Continued from page 68*)

Inc., Research Laboratory, Bayonne, N. J., is now Chemical Engineer, General Electric Co., Large Steam Turbine Generator, Schenectady, N. Y.

Peter J. Doanides, formerly Managing Director and Chief Engineer, Concrete Development Corp. (Pty.), Ltd., Johannesburg, South Africa, is now Executive Vice-President, Vacuum Concrete, Inc., Philadelphia, Pa.

W. P. Dobson, Director of Research, Hydro-Electric Power Commission of Ontario, Toronto, Canada, was given a testimonial dinner on the occasion of his recent retirement. From a staff of seven in 1914, the Research Division has grown to approximately 300 men, 100 of whom are professional engineers and scientists, under the guidance of Dr. Dobson, who had been actively engaged in standardization work in Canada, and elsewhere. He was a member of the first standardization committee of the Canadian Standards Assn. in 1919. In ASTM he represented the Commission for many years, serving on Committees D-9 on Electrical Insulating Materials, and D-18 on Soils for Engineering Purposes. He was a member of the Western New York-Ontario District Council for a number of years.

J. R. Dudley has been named Director of Research and Development at Richardson Co., Melrose Park, Ill. He was formerly with Carwin Co.

James F. Fairman, Vice-President in Charge of Engineering, Consolidated Edison Co. of New York, Inc., has been elected an Honorary Member of the American Institute of Electrical Engineering.

George J. Fischer recently resigned as Director of the Department of Metallurgy, Sam Tour & Co., Inc., New York City, to join the staff of the Polytechnic Institute of Brooklyn.

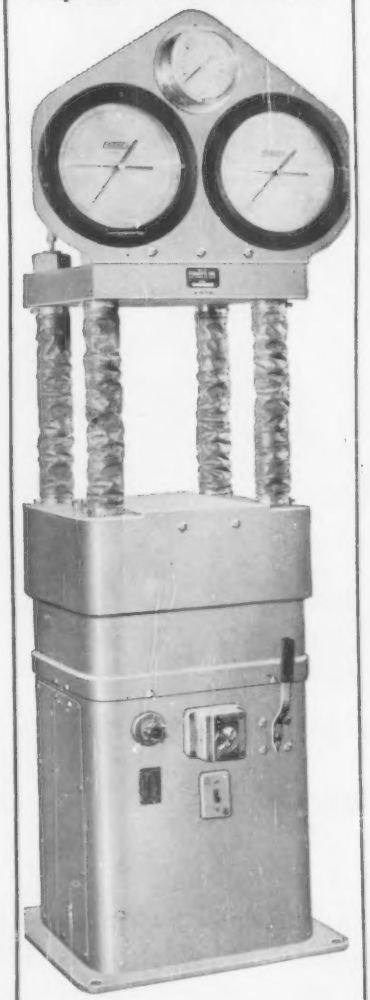
Ernest V. Gent recently retired as Executive Vice-President of the American Zinc Inst., New York City, after service of 20 years as secretary and vice-president. He will continue to serve the Institute as a special consultant. In ASTM Mr. Gent represented AZI since 1936, participating in activities of Committees A-5 on Corrosion of Iron and Steel, B-2 on Non-Ferrous Metals and Alloys, and B-3 on Corrosion of Non-Ferrous Metals and Alloys. **John L. Kimberley,** Secretary of the Institute, has been appointed to succeed Mr. Gent as Executive Vice-President.

Warren E. Glancy has retired as Manager of Development, Hood Rubber Co., Division of the B. F. Goodrich Co., Watertown, Mass. Mr. Glancy represented the company membership in the Society for many years, serving since 1924 on Committee D-13 on Textile Materials, and on Committee D-11 on Rubber and Rubber-Like Materials since 1937.

Morris Goodkind, formerly Bridge Engineer, New Jersey State Highway Dept., Trenton, has opened offices as Consulting Engineer, 39 Lackawanna Pl., Bloomfield, N. J.

FORNEY

Compression & Flexure Testers



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R. K. Gould is the newly appointed editor of *Lubrication Engineering,* the Journal of the American Society of Lubrication Engineers. Associated with The Texas Co. since 1941, Dr. Gould has acquired a broad and varied background in the fields of petroleum processing and industrial lubrication, being currently engaged in technical service activities on industrial lubricants. He also serves as editor of The Texas Co.'s well known monthly magazine *Lubrication.*

LaMotte Grover, Senior Welding Engineer, Applied Engineering Dept., Air Reduction Sales Co., New York City, and winner of the 1955 American Welding Society Adams Lectureship Award, was "saluted" recently by *The Iron Age* as one who has earned well-deserved recognition for "dissecting" the toughest welding problems. Author of the standard industry text: *Manual of Design for Arc Welded Steel Structures,* Mr. Grover has written numerous papers on design and construction methods or welded structures.

Harry W. Highriter, formerly with Vascoly-Ramet Corp., Waukegan, Ill., is now Vice-President and Technical Director, Fansteel Metallurgical Corp., North Chicago, Ill.

Harold O. Hill, Assistant Chief Engineer, Fabricated Steel Construction, Bethlehem Steel Co., Inc., Bethlehem, Pa., recently was presented with an American Petroleum Inst. "Certificate of Appreciation" in recognition of his long outstanding service to the Institute, particularly his leadership and constructive participation in tank standardization.

N. Howell, Professor of Chemistry, Frick Chemical Lab., Princeton University, has been elected to honorary membership in the British Society for Analytical Chemistry.

Arthur E. Juve, Director of Technical Services Research, The B. F. Goodrich Co. Research Center, Brecksville, Ohio, has been elected Chairman of the American Chemical Society Division of Rubber Chemistry.

Paul W. Kabler, Chief of Microbiology, Sanitary Engineering Center, U. S. Public Health Service, Cincinnati, Ohio, was one of four U. S. Public Health Service scientists selected for receipt of the 1955 Kimble Methodology Research Award for outstanding contribution to the field of public health. Selection of Dr. Kabler and Messrs. H. F. Clark, E. E. Geldreich, and H. L. Jeter was based on their development of the use of a membrane filter technique for the bacteriological analysis of water samples, through which it is possible to incubate, count, and identify the bacteria from a sample of water in as little as 16 hr as compared to from 48 to 96 hr by conventional analysis methods. In ASTM Dr. Kabler is quite active in the capacity of liaison

(*Continued on page 72*)

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Overall dimensions:
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Working chamber:
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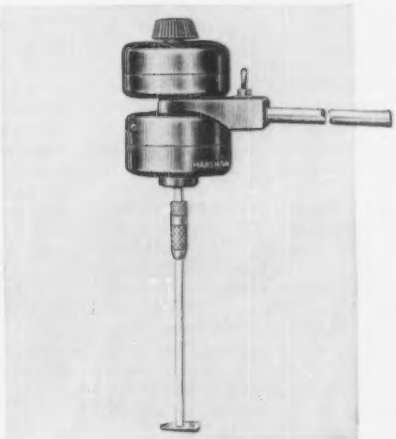

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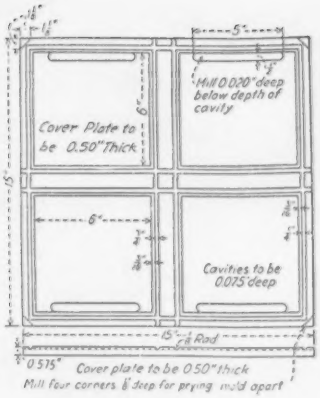
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Standard ASTM and Federal dies for cutting test tensile and tear strength samples and dies for slab curing carried in stock. Write for catalog.

(*Continued from page 70*)

representative of the American Public Health Assn. on Committee D-19 on Industrial Water.

Jacob O. Kamm has been elected President of the Cleveland Quarries Co., Amherst, Ohio, and its subsidiary, Silica Chemicals, Inc. He was previously Executive Vice-President of the firms.

The many friends and committee associates of **Laurence W. Kattelle,** recently retired Assistant Chief Engineer, Walworth Co., will be interested to know that Larry has settled in his summer home in Hudson, Mass. He writes that he has winterized his place there on Lake Boon, and that he and Mrs. Kattelle are very comfortable. During his many years with the Walworth Co. Larry served very constructively on a number of ASTM committees, particularly A-1 on Steel, A-3 on Cast Iron, and A-7 on Malleable-Iron Castings. He was active also in the work of committees functioning under the auspices of the American Standards Assn. His address is—Lower Main St., R.F.D., Hudson, Mass.

H. I. King, formerly with Precast Div., Siporex, Ltd., Toronto, is now Sales Engineer, The Cooksville Co., Ltd., in the same city.

Henry W. Kleindienst has accepted a position as Design Specialist, Republic Aviation Corp., Engineering Research, Farmingdale, L. I., N. Y. He was previously with Chance Vought Aircraft, Inc., Dallas, Tex.

Earl W. Klinger, formerly with Standard Oil Co., Foreign Marketing Coordination, is now with Esso Research and Engineering Co., Marketing Technical Service, Esso Research Center, Linden, N. J.

Kenneth C. Lyon, former Chief of Glass Research, Armstrong Cork Co., has accepted position as Manager of Glass Research and Product Development for Ball Brothers Co., Inc., Muncie, Ind. Dr. Lyon served for many years on ASTM Committee C-14 on Glass and Glass Products as representative of the Armstrong Cork. Co.

Kenneth M. MacKay recently retired as Insulation Engineer, Acme Wire Co., New Haven, Conn. Mr. MacKay had been very active for the past 25 years in the work of Committee D-9 on Electrical Insulating Materials and certain of its subgroups. He writes that he has thoroughly enjoyed his association with the Society and the members and committee members. Mr. MacKay may be addressed at Vero Beach, Fla., P. O. Box 1761.

John A. MacLeod, formerly Power Engineer, United Engineers and Constructors, Inc., Philadelphia, Pa., is now associated with the Bechtel Corp., San Francisco, Calif.

J. Donald MacQuenn has been appointed Associate Staff Engineer in the Metallurgical Laboratory, International Business Machines Corp., Endicott, N. Y. He has been associated with IBM since 1943.

William E. Mahin recently resigned as Vice-President and Director of Research, Hunter Engineering Co., Riverside, Calif. Mr. and Mrs. Mahin have returned to Cambridge, Ohio, where they are establishing a management consulting service in the field of research and development.

H. L. McMullin, Engineer of Tests and Water Supply, Texas and Pacific Railway Co., Dallas, Tex., and Chairman of the American Railway Engineering Assn. Committee on Water, Oil and Sanitation Services, was elected Chairman of the National Association of Railroad Engineers of Tests. Mr. McMullin is active in the ASTM Southwest District Council.

Harry M. Moses, formerly with the U. S. Bureau of Reclamation, Stockton, Calif., is now Project Engineer, Brinckerhoff, Hail and Macdonald, San Mateo, Calif.

Carl W. Muhlenbruch, President, Educational and Technical Consultants, Inc., Evanston, Ill., has been appointed to the Training Committee of Engineers' Council for Professional Development. The Council, which represents the combined influence of all the professional engineering societies which make appointments to it, is currently engaged in developing a plan of professional growth for young engineering graduates. The program includes orientation and training in industry, continued education, integration into the community, professional identification, self appraisal and selected reading. In ASTM Mr. Muhlenbruch currently serves as Secretary of the Chicago District Council.

Perry G. Myer, formerly Statistician, The Russell Manufacturing Co., Alexander City, Ala., is now Quality Control Engineer, International Latex Corp., Manchester, Ga.

Wilbur C. Myers has accepted position as Senior Research Engineer, National Cash Register Co., Electronics Div., Hawthorne, Calif. He was previously with Brush Electronics Co., Div., of Clevite Corp., Cleveland, Ohio.

Emil Ott has been appointed Director of Central Chemical Research and a Vice-President of Food Machinery and Chemical Corp.'s Chemical Divisions. He will be located in the new research center for the chemical divisions near Princeton, N. J. He has been Director of Research at Hercules Powder Co., Wilmington, Del., for the past 16 years.

George F. Pavarini, formerly Vice-President, M. L. Oettel, Inc., New York City, is now associated with Pavarini Construction Co., Inc., in the same city.

Frederick D. Rossini, Silliman Professor, Head of Department of Chemistry, and Director of Petroleum Research Laboratory, Carnegie Institute of Technology, Pittsburgh, Pa., has been appointed Chairman of the National Research Council Division of Chemistry and Chemical Technology.

Julius C. Scharmer, formerly with Mall Tool Co., Chicago, is now Product Engineer, Deepfreeze Appliance Div., Motor Products, North Chicago, Ill.

R. A. Schatzel, Vice-President and Director of Engineering, Rome Cable

Corp., Rome, N. Y., and ASTM Senior Vice-President, recently addressed a Spanish Industrial Management Team attending a special seminar at Syracuse University. He spoke on standardization and the work of ASTM.

Robert T. Sheen, President, Milton Roy Co., Philadelphia, Pa., was elected President of the Instrument Society of America.

Philip Sporn, President, American Gas and Electric Service Corp. and the American Gas and Electric Co., New York City, has been awarded the AIEE John Fritz Medal for 1956. He has been cited as "distinguished engineer, pioneer in utility engineering practice, eminent executive, and human administrator." Born in Galicia, Austria, and a graduate of Columbia University, Mr. Sporn has received many honors and awards for outstanding contributions in the electrical engineering field.

F. P. Spruance, Sr., has resigned as Vice-President of American Chemical Paint Co., Ambler Pa., and is succeeded by F. P. Spruance, Jr.

Walter A. Stadtler has been appointed Director, Manufacturing Engineering, International Business Machines Corp., Poughkeepsie, N. Y.

Donald F. Stoneburner, a recent graduate of the University of Cincinnati, has been appointed to the staff of the Oak Ridge National Laboratory, Oak Ridge, Tenn.

Roger W. Truesdail, President of Truesdail Laboratories, Inc., Los Angeles, Calif,, has been appointed columnist for the Rotary Club national magazine *The Rotarian*. Entitled "Peeps at Things to Come" the column will deal with latest developments in science, progress in new materials, products, and applications. A former President of the American Council of Independent Laboratories, Dr. Truesdail has long been active as a lecturer before scientific societies in this and other countries.

Reed Williams, formerly Works Manager, General Tire and Rubber Co., Wabash, Ind., is now with Dryden Rubber Co., Div. of Sheller Manufacturing Co., Chicago, Ill.

Edmund M. Wise has been appointed Assistant to the Vice-President-Manager of the Development and Research Div., The International Nickel Co., Inc., New York City. F. L. LaQue, Vice-President and Manager of the Division, and very active for many years in ASTM, is currently serving a term on the Board of Directors of the Society. Mr. Wise has represented his company since 1937 on Committees B-2 on Non-Ferrous Metals and Alloys, and B-4 on Metallic Materials for Electrical Heating, Electrical Resistance, and Electrical Contacts.

Samuel Zerfoss has been appointed Chief of the Refractories Section, National Bureau of Standards, Washington, D. C.

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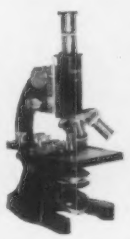

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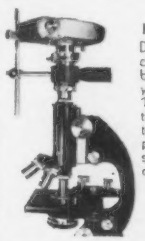

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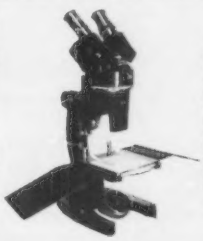

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The following 14 members were elected from November 16 to December 8, 1955, making the total membership 8079... Welcome to ASTM

Note—Names are arranged alphabetically—company members first, then individuals. Your ASTM Yearbook shows the areas covered by the respective Districts.

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Guarnieri, G. J., Staff Research and Development, Thompson Products, Inc., 23555 Euclid Ave., Cleveland 17, Ohio.

Moffett, Robert, A., Director of Research, North American Refractories Co., National City E. Sixth Bldg., Cleveland 14, Ohio.

NEW ENGLAND DISTRICT

Marsden, Peter B., Chemist, Godfrey L. Cabot, Inc., 38 Memorial Dr., Cambridge, Mass.

NEW YORK DISTRICT

Fletcher, Gordon A., Assistant Vice-President, Raymond Concrete Pile Co., 140 Cedar St., New York 6, N. Y. For mail: 33 Sagamore Rd., Bronxville 8, N. Y.

Moss William M., Wire and Insulations Engineer, The Acme Wire Co., Drawer M, Hamden Branch, New Haven, 4, Conn.

Seats, Peter, Manager, Research and Development Div., Thomas Electronics, Inc., 118 Ninth St., Passaic, N. J.

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Dean, Charles A., Quality Control Dept., Russell Manufacturing Co., Alexander City, Ala.

New Mexico Bureau of Revenue, Gasoline Tax Division, Leo George D'Amour, Chemist, 2206 Lomas Blvd., N.E., Albuquerque, N. Mex.

Ryan, P. J., Vice-President in Charge of Southern Div., Reichhold Chemicals, Inc., Tuscaloosa, Ala.

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Burns, S. L., Vice-President, Donald Inspection, Ltd., 1189 Guy St., Montreal, P. Q., Canada.

Evans, J. T., Chief Chemist, Sondes Place Research Laboratories, Ltd., Dorking, Surrey, England.

Hermosa, Loreto B., Civil Engineer, Bureau of Public Highways, Manila, Philippines. For mail: Alah Junction-Kidapawan Road Project Lamitan, Makilala, Cotabato, Philippines.

Nelligan, Jack Edward, Chief Metallurgist, Jenkins' Bros., Ltd., 617 St. Remi St., Montreal 30, P. W., Canada.

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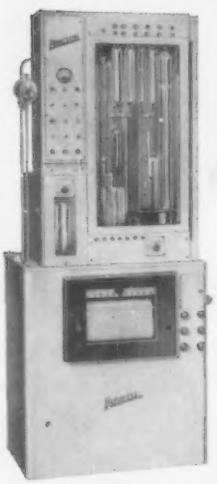

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DEATHS...

Frank L. Bass, Chief Chemist at the Bath, Pa., plant of the Keystone Portland Cement Co., died suddenly on August 21 at his home in Easton, Pa. He was 63 years of age. Member of ASTM since 1949. Mr. Bass had a long career in the cement industry, having served as chemist or chief chemist with Vulcanite, Edison, and Capitol Cement Companies, and for over 25 years with Keystone Portland Cement Co. He was associated also for a number of years with Richard K. Meade, noted cement authority.

Allan E. Chester, Vice-President and Director of Research, Promat Div., Poor and Co., Waukegan, Ill. (November 20, 1955). Representative of company membership since 1950. An outstanding research chemist, Dr. Chester held many patents in the fields of electrochemistry and vitreous enameling.

Allan W. Dow, Consulting Paving Engineer, New York City and Bridgewater, Conn. (December 8, 1955). Member since 1898. (See obituary on page 19.)

James H. Holden, Chief Chemist, Pittsburgh Testing Laboratory, Pittsburgh, Pa. Representative of company membership since 1948, serving on Committees A-9 on Ferro-Alloys, D-5 on Coal and Coke, D-8 on Bituminous Waterproofing and Roofing Materials, D-22 on Methods of Atmospheric Sampling and Analysis, and E-3 on Chemical Analysis of Metals.

C. M. Houck, Chairman of the Board and former President, Pittsburgh Testing Laboratory, Pittsburgh, Pa. Member since 1939. Mr. Houck had been much interested in the work of the Society, as had other PTL executives, and arranged for many of their associates throughout the country to keep in close touch with ASTM activities through individual memberships. At the 1955 Annual Meeting of the Society he accepted the 50-year membership certificate for his company.

Robert A. Kinzie, Vice-President and General Manager, Santa Cruz Portland Cement Co., San Francisco, Calif. (October 22, 1955). A member of the organizing group of the ASTM Northern California District Council, Mr. Kinzie has served continuously on the Council for the past 25 years. Always ready with help, he will be greatly missed by members of this local group.

Paul G. Weiller, Consulting Engineer, New York City (November 2, 1955). Member since 1945.

R. V. Widemann, Chemical Engineer, Institut de Ceramique Française, Sèvres, France. Member since 1948.

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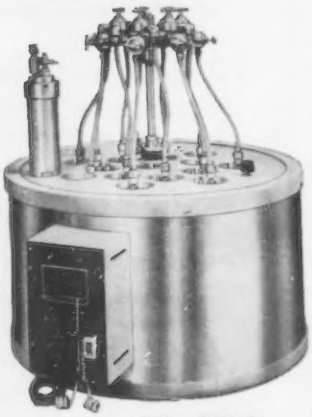

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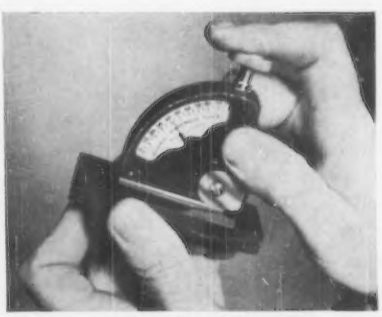

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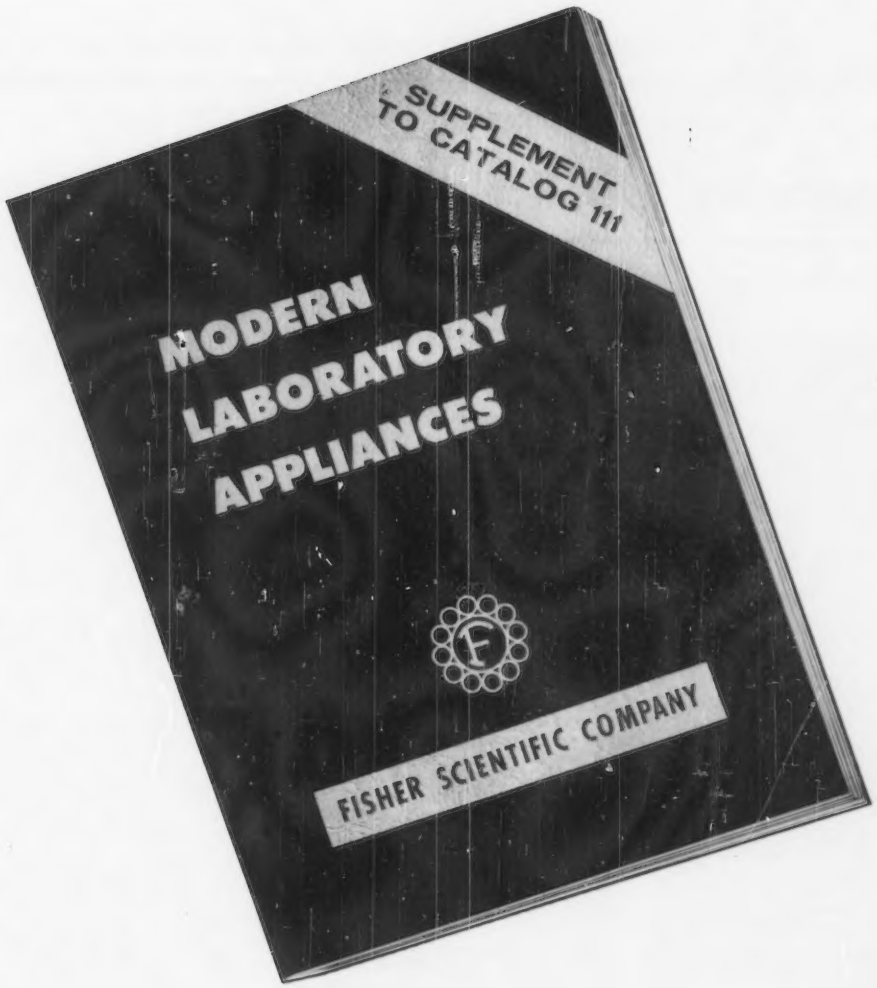

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Still—Laboratory-type centrifugal molecular still offers the only means of separating heat-sensitive materials of high molecular weights up to 1200.
Consolidated Electrodynamics Corp., 300 N. Sierra Madre Villa, Pasadena 15, Calif.

Flame-Resistant Curtains and Blankets—Made from impregnated canvas and designed to provide protection from intense heat, arc flash, molten splash, flying chips, and scale.
Eastern Equipment Co., Inc., Willow Grove, Pa.

Air Filter—Entirely new, lightweight, fully automatic, and self-adjusting air filter.
EMCO Pneumatic Corp., 1317–1319 Locust St., Des Moines, Iowa.

Dielectric Oven—New radio-frequency oven was primarily designed for experimental laboratory use for instantaneous drying of sample quantities of various solid and liquid materials
Erdco Engineering Corp., Addison, Ill.

Safety Rubber Stoppers—With the new line of Fisher Safety Rubber Stoppers, thermometers, glassware, and tubing go in as easy as pie. Although the holes have been enlarged for safer insertions, they retain their sealing properties.
Fisher Scientific Co., 717 Forbes St., Pittsburgh 19, Pa.

Psychrometer—Portable psychrometer, motorized, battery operated for use in accurately obtaining relative humidity measurements.
G. M. Manufacturing Co., 50 W. 3rd St., New York 12, N. Y.

Non-Residual Molding Lubricant—A synthetic wax lubricant, Acrawax C, an organic product which fires-off completely.
Glyco Products Co., Inc., Empire State Bldg., New York 1, N. Y.

Non-Automatic Enlarger—A single-lens reflex system with built-in Test Negative allows instant focusing without removing the actual negative.
Karl Heitz Inc., 480 Lexington Ave., New York 17, N. Y.

Autoclave—High-pressure autoclave with a water-cooled drive shaft.
High Pressure Equipment Co., Inc., 1222 Linden St., Erie, Pa.

Automatic Quality Control—A new method of control through the use of wavelength absorption from a continuous flow of materials or finished products is now possible by the use of Spectrostats.
Kaye Development Co., South Norwalk, Conn.

Industrial Balancer—Will dynamically and kinetically balance any rotor weighing as much as a 2½ ton locomotive traction generator or as little as a 1-lb flywheel, quickly, easily, and with greater safety.
Merrill Engineering Labs., 1240 Lincoln St., Denver 3, Colo.

Autrometer—Improved Norelco Autrometer, multi-element indexing X-ray Spectrograph, covers a range of 71 elements in the atomic scale and gives percentages of as many as 24 in a specimen.
North American Philips Co., Inc., 750 S. Fulton Ave., Mount Vernon, N. Y.

X-Ray Inspection—X-ray tube of recent design has been combined with a unique electronic intensifier which increases image brightness 1200 times above the ordinary fluoroscopic screen, to provide visual and photographic inspection at remote points over closed TV circuits.
North American Philips Co., Inc., Research & Control Instruments Div., 750 S. Fulton Ave., Mount Vernon, N. Y.

Long-Lived Radioisotope of Aluminum—Limited supply of the recently discovered first long-lived radioisotope of aluminum Al^{26} decays by positron emission, positive charged electrons of 1.30 Mev energy and with a half life of -10^5 years.
Nuclear Science and Engineering Corp., P. O. Box 10901, Pittsburgh, Pa.

Radiation Analyzer—Used with a scaler or rate-meter and scintillation counter to make possible more precise measurements of gamma emitting radioactive samples.
Nuclear Instrument and Chemical Corp., 229 W. Erie St., Chicago 10, Ill.

Water Conditioner—Eliminates scale and corrosion without chemicals.
Packard Water Conditioner Div., Inc., 2220 W. Beaver St., Jacksonville 9, Fla.

Titration—Redesigned for closer accuracy and more convenience in both aqueous and nonaqueous titrations.
Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill.

Miniature Resistors—Precision wirewound miniature resistors engineered expressly for use with printed circuits.
Resistance Products Co., 914 S. 13th St., Harrisburg, Pa.

Vernier Caliper—Dull-chrome finished vernier slides eliminate glare and reflection given off by ordinary bright steel, resulting in faster, more accurate readings and measurements.
George Scherr Co., Inc., 200 Lafayette St., New York 12, N. Y.

Differential Colorimeter—Makes color measurements with a sensitivity to color differences exceeding that of the human eye.
Manufacturers Engineering & Equipment Corp., Hatboro, Penna.

Scoops, Pails and Funnels—Stainless steel scoops, pails, and funnels now available for immediate delivery from stock.
Star Stainless Screw Co., 699 Union Blvd., Paterson 2, N. J.

Hardness Tester—Brinell hardness tester with a paint spray attachment synchronized with the testing cycle of the machine so that relative hardness of parts is automatically indicated by a spot of paint.
Steel City Testing Machines Inc., 8817 Lyndon Ave., Detroit, Mich.

Hardness Tester—New air operated Brinell hardness tester features operating ease and accuracy.
Tinius Olsen Testing Machine Co., 6061 Easton Rd., Willow Grove, Pa.

CATALOGS AND LITERATURE

Special Metals—The production and processing of made-to-order metals in experimental quantities is described in a 16-page booklet entitled "Precision Metals Services."
Allied Products Div., Hamilton Watch Co., Lancaster, Pa.

Standard Conversion Tables—"Standard Conversion Tables" gives thermocouple temperature-millivolt equivalents.
Barber-Colman Co., Rockford, Ill.

(Continued on page 87)

Kodak reports to laboratories on:

what you could have learned about our photoconductive cell . . . how to bring somebody else's slide lecture back home . . . half-second butyrate on the road

PbS on a slip of glass

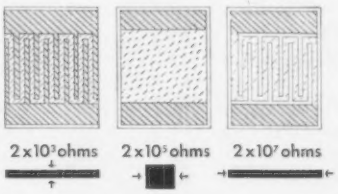
A little more than a year ago, in an advertisement that looked much like this one, there appeared an ecstatic announcement of a new type of photoconductive cell, y-clept *Kodak Ektron Detector*. No literature was offered—just the name of a man who could supply ordering information and transact business. If you had been one of those not repelled by such antediluvian merchandising technique; if, on the contrary, you had been sufficiently aroused to invest the price of an evening at a night club in a little .030″-thick rectangle of glass coated with lead sulfide, you might have found out for yourself some of the following facts about it:

Response extends from a few Å in the x-ray region through the whole ultraviolet and the visible, all the way to 3.5μ in the infrared. Probably the reason response stops there is the infrared transparency of lead sulfide. It can't very well respond to radiation it can't stop.

The sensitive area can be in the shape of a square a quarter millimeter on a side, a rectangle as big as a playing card, an etching of moonrise over Fujiyama, or a draftsman's nightmare inspired by Boolian algebra. It's just a coating on a plate —no envelope, nothing to shake loose. Moreover, signal response is strangely independent of sensitive area size. (Almost. At a given point in the range where response is linear with bias voltage, the signal is roughly proportional to the 0.1 power of area.)

Sensitivity of the surface is so uniform that, in general, an 0.25 mm² spot scanning a 250 mm² cell surface produces signals varying no more than 50% from the mean. Much better, of course, with a bigger spot.

Signal-to-noise ratio with infrared radiation is high. Cooling to dry ice temperatures boosts signal response much more than noise. Also, cutting current density cuts noise. Just by pattern changes, a cell of given size can have a 10,000:1 range of impedance, viz.:



Time constant may be anywhere from 400 to 1000 μsec. depending on the individual cell. At 60 C, frequency response is flat from 0 to 500 cycles; at 20 C, a drop is already noticeable at 120 cycles. When refrigerated for supersensitivity, drop in response with illumination chopping frequency is continuous. If the system can be operated at a sufficiently high frequency, response becomes virtually independent of temperature.

Now that a decent interval has elapsed for ambitious souls to pioneer with a new plaything, we have a booklet. It summarizes the properties of Kodak Ektron Detectors, *compares them quantitatively with other photocells, and gives some basic circuits and optical arrangements for them. For a free copy, address Eastman Kodak Company, Special Products Sales Division, Rochester 4, N. Y.*

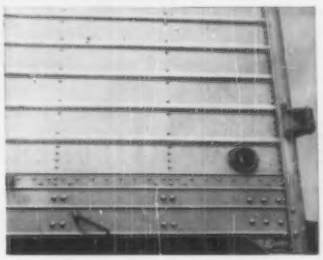
Convention trophies

Bumped into a lad the other day who is director of photo services at one of the big Middle Western universities. It was at a meeting of a technical society, and he had spied us in the act of outwitting a speaker who was impressing the audience by zipping slide after slide of big, fat tables of numerical data onto the screen. There we sat in the dark with a little camera, popping away at each slide so that when we got home we could take our own sweet time deciding just how impressed to be.

We thought we would have a chance to expound to the fellow a little on film, aperture, and shutter speed involved in this photographic feat, but it turned out this type of cagey operation is straight routine with him and we couldn't tell him a thing he didn't know already. One of the regular duties of his office is to supply staff members with cameras to catch the slides at meetings.

With any luck and a steady hand, a camera no more elaborate than the Kodak Pony 135, Model C, *which comes with an f/3.5 lens for $33.75, should pick up readable copies of slides on* Kodak Tri-X Film *when shot wide open at 1/25 sec. from a point in the room where the screen image just fills the finder. It could provide something more definite to bring home from a meeting than a feeling of solidarity with one's discipline. (Caution: copying a man's slides without his permission could conceivably earn one a punch in the nose.)*

Skin for aluminum



This is the freshly washed side of an aluminum truck trailer. The portion on the left had once been sprayed for demonstration with a clear lacquer made from *Eastman Half-Second Butyrate*, and the portion on the right left bare. Note the difference brought out by 16 months and 128,000 miles of weather, flying gravel, and road salt. There was also a dent that penetrated the lacquer but failed to start it peeling or chipping.

In summary, aluminum resists the elements till kingdom come, but a coat of Egyptian Lacquer Company's (South Kearny, N. J.) new Half-Second Butyrate-*based product helps to keep it clean and unpitted while waiting. Full information about* Eastman Half-Second Butyrate *is obtainable from Eastman Chemical Products, Inc., Kingsport, Tenn. (Subsidiary of Eastman Kodak Company).*

Price quoted includes Federal Tax and is subject to change without notice.

This is one of a series of reports on the many products and services with which the Eastman Kodak Company and its divisions are . . . *serving laboratories everywhere*

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ELECTRIC HEAT SOURCE

Simplifies Your

ASTM Softening-Point Tests

QUICKER
More Accurate!

Once the proper current setting is established for a given container, the same value may be set on ammeter for future tests.

For ASTM Tests:
D 36 - 26; D 61; E 28

Aids in Softening-Point Tests of bituminous materials by eliminating trial and error adjustments of gas-heated sources. An ammeter and variac controller permit even increase of heat. Light source behind sample improves sample visibility. Heating ring rated 500 watts, 115 volts a. c. Dimensions: 12-¼ x 14-¾ x 15 in. high. Designed by J. J. McManus, Allied Chemical & Dye Corp.

Write for Bulletin 2246 E

AMERICAN INSTRUMENT CO. Inc.

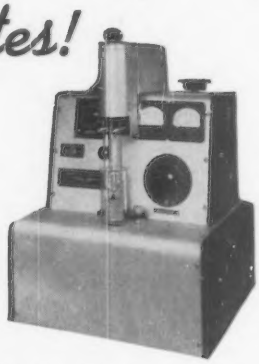
Silver Spring, Maryland

Copper Assay in 8 Minutes!

NEW

Eberbach

ULTRA-SPEED
ELECTRO-ANALYZER



Equals production rate of 4 positions on conventional apparatus. For example, in a copper assay, an analytically complete deposition of a one gram sample is accomplished in 8 minutes. Best equipment and techniques previously employed require 30 to 60 minutes.

Request Bulletin 390-F

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Also Available in Capacities
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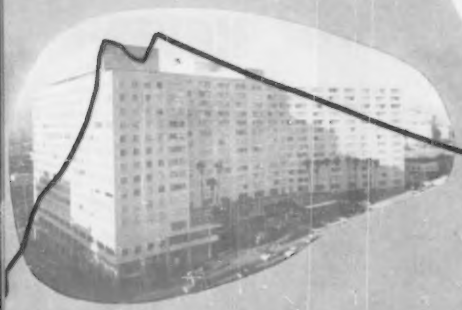
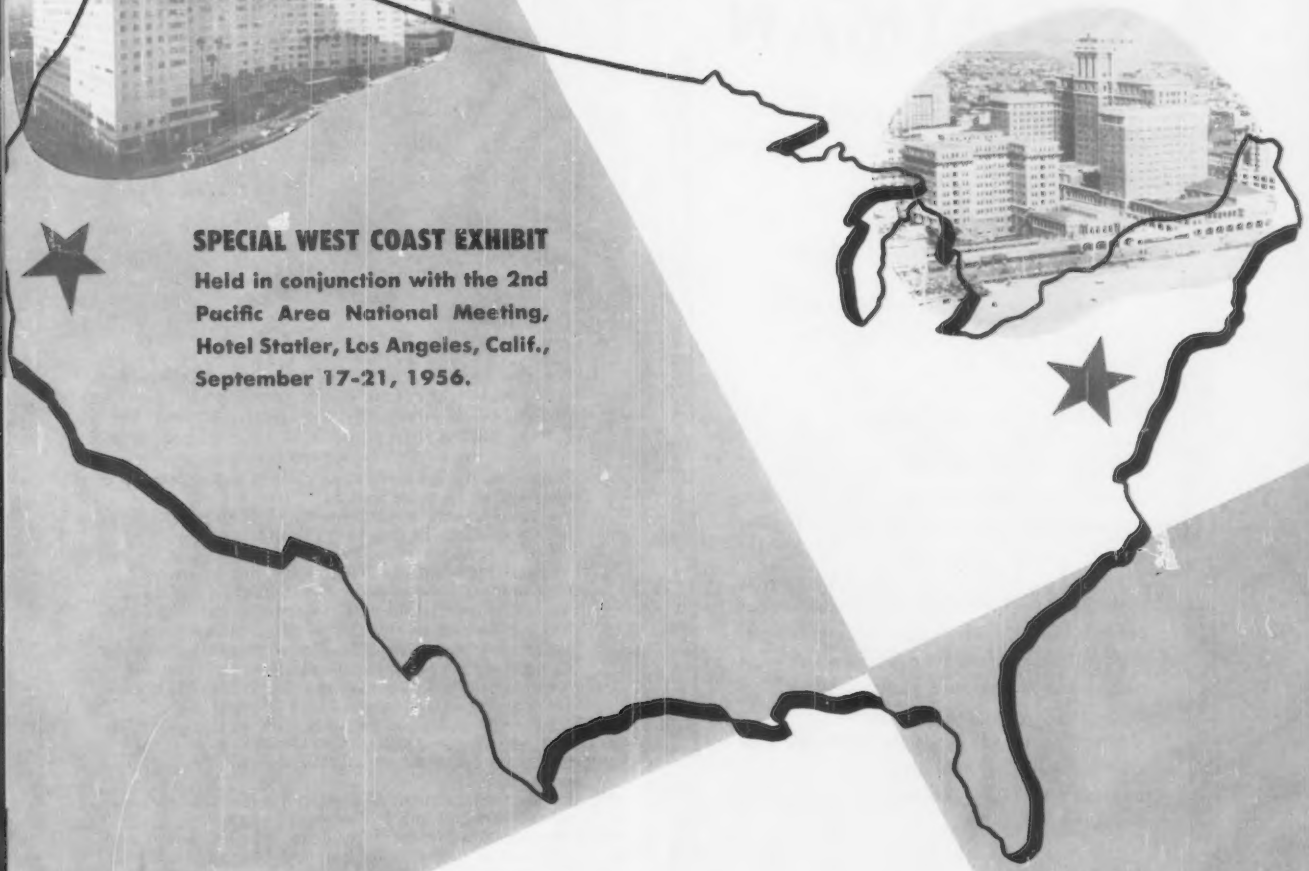
HOLYOKE, MASSACHUSETTS

Two ASTM Exhibits in 1956

12th EXHIBIT OF TESTING AND SCIENTIFIC APPARATUS AND LABORATORY SUPPLIES

Held in conjunction with the 59th Annual Meeting, Chalfonte-Haddon Hall, Atlantic City, N. J., June 18-22, 1956





SPECIAL WEST COAST EXHIBIT

Held in conjunction with the 2nd Pacific Area National Meeting, Hotel Statler, Los Angeles, Calif., September 17-21, 1956.

Two important exhibits for reaching the men who buy and use the production of the mushrooming apparatus industry.

American Society for Testing Materials

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Filter Paper for Metal Analyses

For the analysis of ferrous and non-ferrous metals, WHATMAN Filter Papers have long been favored.

Chemists in the laboratories of Blast Furnaces, Open Hearths, Bessemers and Electric Furnaces use WHATMAN Filter Papers to determine phosphorus, silica, sulfur as well as the alloying constituents of tool and other complex steels.

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MODEL XXI

Uses are varied and many for the SARGENT POLAROGRAPH

1. For the routine analysis of non-ferrous alloys and ores when determining minor constituents including copper, lead, cadmium, zinc, manganese, iron and cobalt.
2. For the routine determination of lead, copper, nickel, manganese and cobalt in ferrous alloys.
3. For the analytical control of plating baths, notably in the field of precious metals.
4. For trace metal measurements in food products, in body fluids and in petroleum products.
5. For the analysis of source materials and processed products for a variety of hormones and vitamins.
6. For the identification and estimation of numerous substances of nutritional and biological regulatory function, supporting or replacing biological assay.
7. For the determination of halides and sulfate groups by titration with a polarized electrode.
8. For the analytical measurement of innumerable organic compounds containing reducible groups.
9. For specific industrial controls such as the estimation of aldehydes in alcoholic products, the quantitative differentiation of sugars and the control of aging quality in sugars.
10. For the measurement of dissolved oxygen, oxygen demand and metal ions in water and sewage.
11. For many uncommon analyses for which classical procedures are unavailable, less accurate and slower.
12. For the investigation and control of commercial reduction processes.
13. For thermodynamic investigations relating to states of ionic aggregations, mobilities and diffusion rates, solubilities, reaction rates and equilibrium constants.

For a complete description of the Sargent Polarograph Model XXI, write today.

S-29303 POLAROGRAPH—Model XXI Visible Chart Recording, Sargent. For operation from 115 Volt 50/60 cycle circuits.....**$1875.00**

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SOUTHWESTERN DIVISION, 5915 PEELER STREET, DALLAS 19, TEXAS
SOUTHEASTERN DIVISION, 3125 SEVENTH AVE., N., BIRMINGHAM 4, ALA.

(Continued on page 82)

Optical Aids—64 pages, over 1000 optical items—factual information on all types of optical instruments and components.
Edmund Scientific Corp., Barrington 7, N. J.

Test Chamber—Line of "Weather-Lab" Environmental test chambers is described in a new four-page *Bulletin HT-10.*
Hudson Bay Co. Div. of Labline Inc., 3070 W. Grand Ave., Chicago 22, Ill.

Film Evaporator—New rotary film evaporator is ideal for separating heat and air sensitive solutions.
Labline Inc., 3070-82 W. Grand Ave., Chicago 22, Ill.

Radiography—*Bulletin P-196* available from Metal & Thermit Corp., describes the new Kel-Ray Projectors for industrial radiography with gamma rays.
Metal & Thermit Corp., 100 E. 42nd St., New York 17, N. Y.

Pumps—*Bulletin No. 855* describes new lines of controlled volume pumps for "downhill" metering of liquids and gases.
Milton Roy Co., Station M 1300 E. Mermaid Lane, Philadelphia 18, Pa.

Quarter Second Recorder—Data sheet 10.2-21 describes new "split second" ElectroniK strip chart instrument having full scale pen speed of ¼ second facilitating recording of rapidly changing variables.
Minneapolis-Honeywell Regulator Co., Wayne & Windrim Aves., Philadelphia 44, Pa.

High Temperature Bath—*Bulletin 668*, a two-page leaflet describing the Hy-Temp Aging Bath.
Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill.

Laboratory Apparatus—New edition of "What's New for the Laboratory" features relative humidity apparatus and freeze-drying equipment.
Scientific Glass Apparatus Co., Inc., Bloomfield, N. J.

Concrete Testing—*Bulletin CT-711* on portable concrete testing machines, flexure attachments and accessories.
Soiltest Inc., 4711 W. North Ave., Chicago 39, Ill.

Instrument Company News—George V. Boselli has joined the Instrument Division Sales Engineering Department of Thomas A. Edison, Inc.

NEWS OF LABORATORIES

Miss Rita Connolly, Spectroscopist, has just been appointed to the staff of the infrared laboratory at Electrical Testing Laboratories Inc., New York, N. Y., where she will operate the company's new Perkin-Elmer Double Beam Recording Spectrophotometer and assist in analyzing test specimens.

Dr. Jerome Kruger, a physical chemist, has joined the Corrosion Section of the Metallurgy Division of the National Bureau of Standards, Washington, D. C. Dr. Kruger will direct a new Bureau project for studying the surface reactions of metal single crystals in selected environments.

The United States Testing Co., announces the opening of a complete cotton-fiber laboratory in Lubbock, Texas.

ACCO products

Wilson "Tukon" Micro Hardness Testers

A model for every range of pyramid testing
Model LR—Floor model for Micro and Macro Hardness testing
Model FB—Floor model for Micro Hardness testing only
Model MO—Table Model for Micro Hardness testing only

These "Tukon" models meet every fine test requirement

• WILSON "TUKON" Micro Hardness Testers are unexcelled for testing metallic and non-metallic parts such as fine wire, small precision parts, thin metal, shallow superficially hardened surfaces, jewels, plastics, glass, etc.

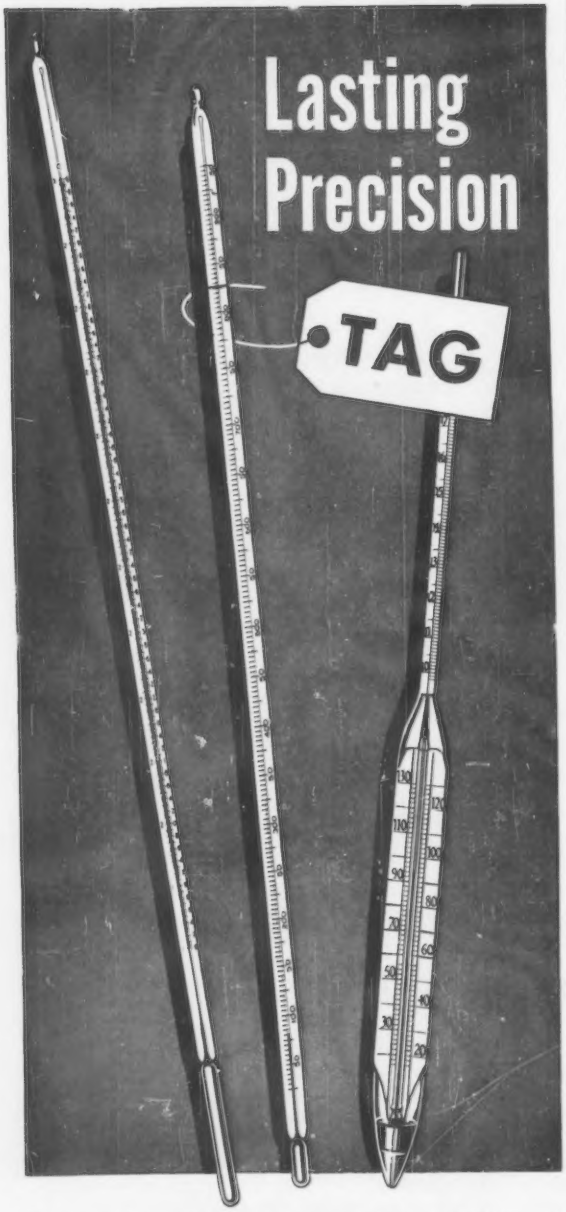
The three models pictured cover the entire range of diamond pyramid testing—with both Knoop and 136 degree Diamond Pyramid Indentors.

Proper selection of the proper model for your particular requirement depends on the type and thickness of work to be tested, range of loads, purposes for which the machine is to be used—research or control, other hardness testing equipment available and whether a combination of micro and macro hardness testing is required.

We invite you to consult with WILSON engineers on your hardness testing problem. There is no obligation. Write for **Booklet DH-114** *on WILSON "TUKON" Micro Hardness Testers.*

ACCO Wilson Mechanical Instrument Division
AMERICAN CHAIN & CABLE
230-C Park Avenue, New York 17, N. Y.

WILSON "ROCKWELL" and "TUKON" Hardness Testers



Favorites the world over because of their readability and permanent accuracy TAG etched stem thermometers are available in A.S.T.M., Extreme Precision, and Standard Grades—as well as in Armored Types for special applications. Also A.P.I. Scale Hydrometers in plain or combined forms, and a precision grade for general use. Catalog gladly sent on request. WESTON Electrical Instrument Corporation, 617 Frelinghuysen Avenue, Newark 5, New Jersey . . . *manufacturers of Weston and TAG Instruments.*

WESTON *Instruments*

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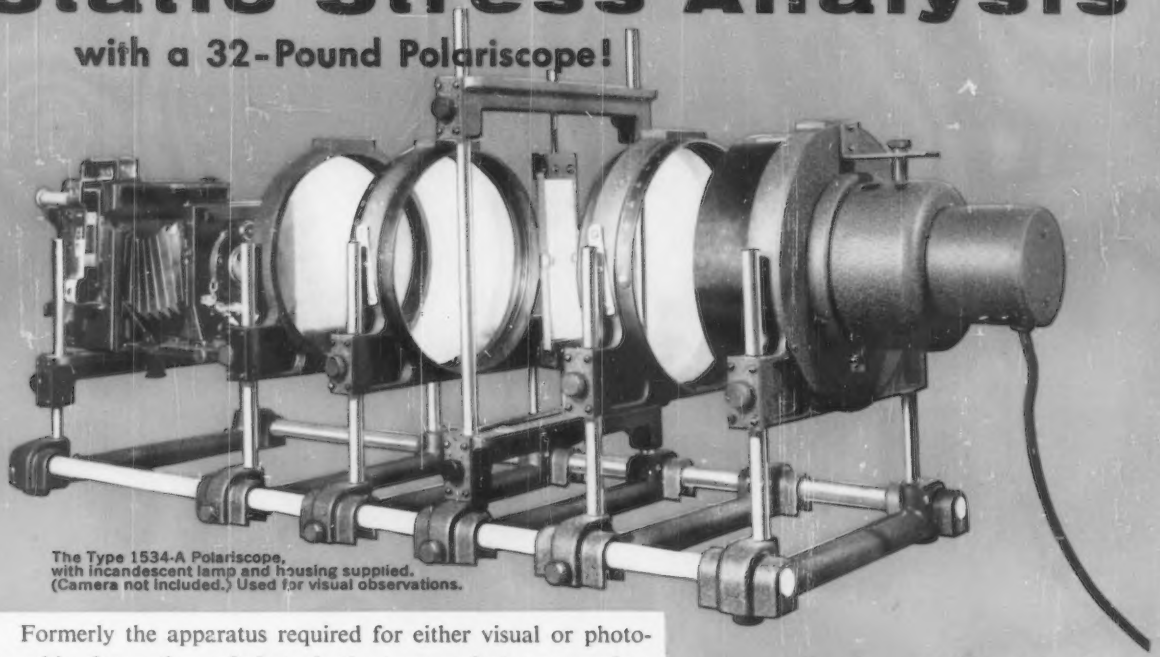
Dynamic or Static Stress Analysis

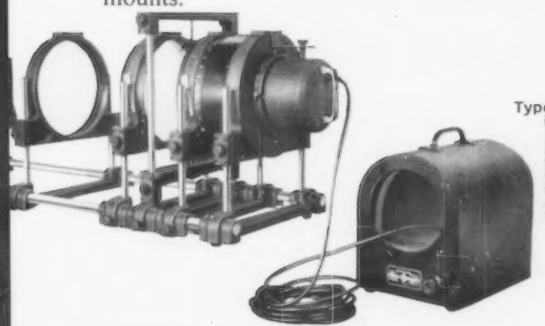
with a 32-Pound Polariscope!



The Type 1534-A Polariscope, with incandescent lamp and housing supplied. (Camera not included.) Used for visual observations.

Formerly the apparatus required for either visual or photographic observations of photoelastic stress analysis was cumbersome, very expensive, excessively bulky and heavy, and required permanent installation.

The G-R Polariscope is a unique solution to the problem. With its auxiliary STROBOLUME high-intensity stroboscopic light source, the exposure time is reduced to 40 microseconds instead of the usual several minutes required with conventional polariscopes. The effects of any external vibration are completely masked by this extremely short exposure. The polariscope can then consist of an assembly of light rods, supports and disc mounts.



Type 1532-B Strobolume in place, with its power supply at right. Forty microsecond flash duration provides ample illumination for use with any camera with an f/4.5 lens.

The Type 1534-A Polariscope has a number of unusual features:

★ Unusually large field of eight inches . . . allows use of models large enough for easy fabrication and handling . . . permits more detailed analysis than is possible with small models

★ Very simple means for making instantaneous photographs of dynamic stresses . . . any standard camera with a lens as fast as f/4.5 is suitable.

★ Compact enough to mount directly on the bed of many standard testing machines

★ Portable and readily put together or taken apart . . . will fit in any compact carrying case . . . ideal for lectures and other demonstrations

★ Flexible design makes changing from plane to circular polarization very simple . . . easily removed quarter plates and polarizers

★ Much simpler than an optical bench . . . wide range of vertical and horizontal adjustments

★ LOW COST: $490.00 with incandescent illumination for visual observations. Auxiliary high-speed STROBOLUME (1/25,000 second flash) for photographic studies: $265.00

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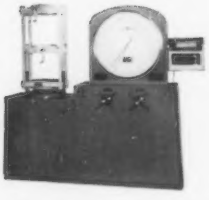
This is just one of the many reasons why it will pay you to get the facts about Olsen hydraulic Super "L" or electro-mechanical ElecTmatic testing machines before you decide.

Write for a copy of Bulletin 47 today.



When an Olsen U.T.M. is used with an electronic recorder the ratio of test ranges can be doubled. Write for information.

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Testing & Balancing Machines

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